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WAR SURGERY

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WAR SURGERY

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BY

EDMOND DELORME

MÉDECIN INSPECTEUR GÉNÉRAL DE L'ARMÉE
ANCIEN PRÉSIDENT DU COMITÉ CONSULTATIF DE SANTÉ DE L'ARMÉE
MEMBRE DE L'ACADÉMIE DE MÉDECINE
MEMBRE ET ANCIEN PRÉSIDENT DE LA SOCIÉTÉ DE CHIRURGIE

TRANSLATED BY

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WITH ILLUSTRATIONS



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EXTRACTS FROM AUTHOR'S PREFACE

* * * * *

Unity of doctrine is absolutely essential. This I set forth in my "Advice to Surgeons." In order to avoid the excess of operative measures which has been seen in recent wars, it was urgent to lay stress on the almost uniform conservatism of our present surgery, but a rapid, synthetic outline was not sufficient. It was necessary to complete it by information on the special aspect of the wounds we see, on their complications, and also by adequate details with regard to the best methods for us to follow. Therefore the present work became a necessary supplement.

It is intended both for beginners and also for those surgeons whose everyday practice—often specialized—has not allowed them to follow the advances made in military surgery. I have been obliged to give a scientific form to many descriptions, and to lay stress on legitimate reasons for the methods I have advised; I was also forced to give up the concrete, imperative form, which is excellent in addressing young surgeons just entering the profession, but insufficient to secure conviction from those on whom, in the rear, the whole

weight of the most important treatment of the wounded will fall.

I hope both these categories will follow my writings in the few moments of leisure left them by their daily work. . . . They will be able to turn to account what the book teaches them, and our brave wounded will be benefited.

* * * * *

TRANSLATOR'S NOTE

IN translating the work of so distinguished a military surgeon as Dr. Delorme, I have endeavoured so far as possible to keep closely to the French text.

H. DE MÉRIC.

CONTENTS

CHAPTER	PAGE
I. WEAPONS AND PROJECTILES (RIFLES) - - -	I
II. PROJECTILES (GUNS) - - -	16
III. WOUNDS OF DIFFERENT TISSUES - - -	23
IV. WOUNDS OF ARTERIES - - -	36
V. WOUNDS OF THE NERVES - - -	54
VI. FOREIGN BODIES - - -	61
VII. BONY LESIONS OF THE DIAPHYSES - - -	71
VIII. LESIONS OF THE ARTICULATIONS - - -	103
IX. GENERAL COMPLICATIONS OF WOUNDS BY FIRE- ARMS - - - - -	113
X. WOUNDS BY LARGE PROJECTILES AND THEIR FRAGMENTS - - - - -	123
XI. AMPUTATION - - - - -	126
XII. WOUNDS OF THE SKULL AND BRAIN - - -	128
XIII. WOUNDS OF THE FACE - - - - -	145
XIV. WOUNDS OF THE NECK - - - - -	152
XV. WOUNDS OF THE CHEST - - - - -	158
XVI. WOUNDS OF THE ABDOMEN - - - - -	167

CHAPTER	PAGE
XVII. WOUNDS OF THE LUMBAR REGION AND OF THE KIDNEYS - - - - -	181
XVIII. WOUNDS IN THE REGION OF THE PELVIS -	184
XIX. WOUNDS OF THE VERTEBRAL COLUMN AND OF THE SPINAL CORD - - - - -	190
XX. WOUNDS OF THE UPPER LIMBS - - -	197
XXI. WOUNDS OF THE LOWER LIMBS - - -	217
INDEX - - - - -	243

WAR SURGERY

CHAPTER I

WEAPONS

THE weapons used in warfare are either *defensive* (helmets, cuirass) or *offensive* (cold steel, firearms). We will not stop to consider defensive ones, as projectiles from modern rifles go through them at whatever distance an action is engaged.

Cold Steel.

Amongst cold steel weapons we may include the bayonet, the sword-bayonet, the sabre-bayonet, the cavalry sword, the lance.

Bayonets have a straight styloid blade with a slender point, two sides (Lebel rifle), and sharp serrated edges. Some are merely a kind of hunting-knife (Germany, Austria, England, Italy).

Bayonets are employed as puncturing or stabbing weapons, the direction being specially towards the abdomen or the upper part of the lower limbs. The serious injuries thus inflicted are somewhat analogous to wounds made by pointed instruments, or by those that at the same time are pointed and cutting.

During the Balkan War bayonet injuries were very frequently observed. In certain battles they reached a proportion of 10 per cent. of the wounded. The injured regions

were mainly the body, the abdomen, the upper part of the lower limbs.

The *sabre* or *sword*, having a blade with hollow sides, straight or curved, is used for stabbing and thrusting in the same way as the bayonet, or as a cutting weapon. The wounds it inflicts are generally numerous (two, four, twenty). They are usually found on the head, the right elbow, the upper part of the left arm.

The *lance* is a pointed weapon that has considerable power behind it. The head of the French lance is 15 centimetres long (5·9 inches) and 2 centimetres (0·7 inch) in diameter; its section is quadrangular. The head of the German lance is 30 centimetres long (11·8 inches) and 15 millimetres (0·6 inch) in diameter; its section is triangular. In the attack the point of the lance is directed against the trunk.

Wounds by cold steel, rarely observed during relatively recent wars, now tend to increase in number. During the war of 1870 only 600 cases were recorded among 98,000 wounded. They now occur in the proportion of 5 per cent.

Weapons of Offence (Firearms).

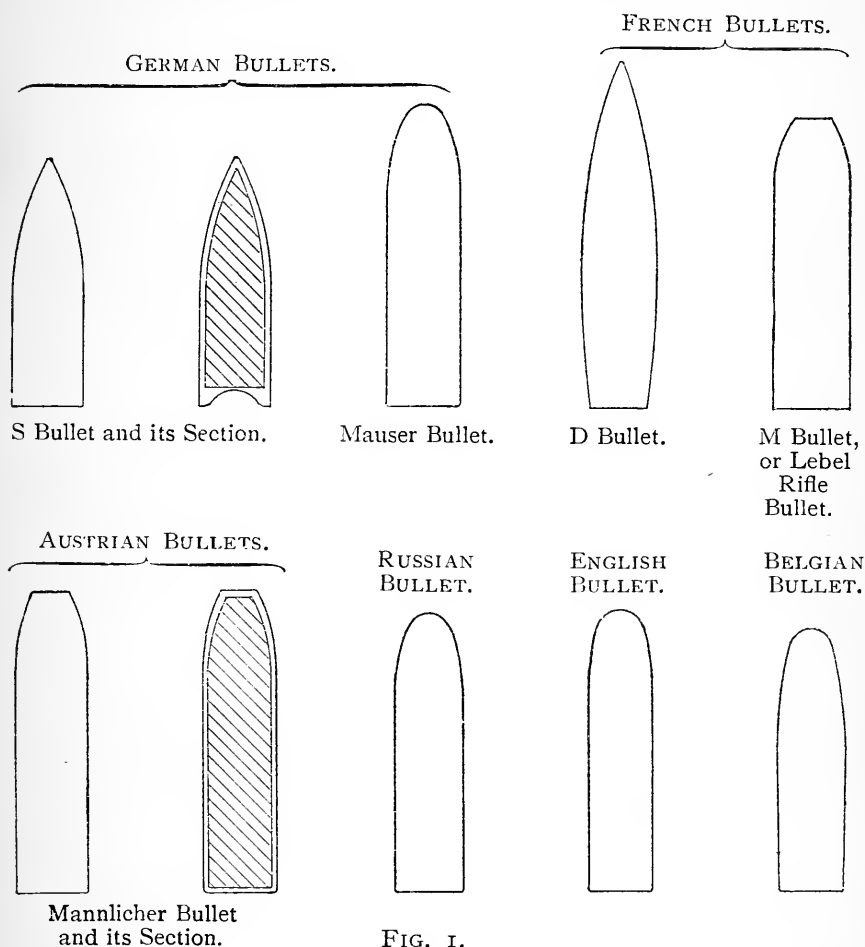
These comprise rifles, mitrailleuses, guns. The projectiles from these arms are alone of interest to the military surgeon.

Projectiles of Firearms carried by the Soldier.

They are projected by means of smokeless powder, which has increased their velocity. At the present time they are pointed instead of conical cylinders. Their calibre has been reduced from 11 to 8, and even to 6·5 millimetres (from 0·43 to 0·31, and even 0·25 inch) (D bullet). Their length, on the contrary, has increased: from 2 calibres it has risen to 3, 4, and even 5 (D bullet). Their weight, on the other

hand; has diminished: from 25 grammes (386 grains) to 15 grammes (231 grains), to 12.50 grammes (193 grains) (bullet D), to 10 grammes (154 grains) (bullet S).

Some bullets are of a uniform composition of soft or



hardened lead, steel, or copper; others have a protective envelope. The central nucleus of hardened lead is covered by a casing of steel, copper, nickel, or nickel silver, which is either closed or open at the base. We shall only describe the smaller projectiles used by the belligerent Powers.

The German S Bullet.—The S bullet of the German Mauser is a pointed cylinder, ogival-shaped projectile of hardened lead, surrounded by an envelope of soft steel plated with nickel. Its cylindrical part hardly exceeds a fourth of its total length; its point, which measures 19 millimetres (0·75 inch), is very tapering, and ends in a very small flat apex, measuring about 1 millimetre (0·04 inch). Its calibre is 7 millimetres (0·28 inch), its length 28 millimetres (1·10 inches), its weight 10 grammes (154 grains). The S bullet is shorter and lighter than the D bullet.

The **Austrian Bullet**, of the Austrian Mannlicher rifle, is formed of hardened lead compressed in a steel wrapper. It weighs 15·8 grammes (244 grains); it is 31·8 millimetres long (1·25 inch), and 7·9 millimetres (0·31 inch) in diameter. It is conico-cylindrical, with a truncated extremity, which is rounded and not tapering.

The French Bullet.—The D bullet is of brass, without envelope; it is biogival, the point being very sharp in front, and the bullet truncated at its base. Its calibre is 8 millimetres (0·31 inch), its length 39 millimetres (1·53 inches), its weight 12·80 grammes (197 grains).

The M bullet consists of a nucleus of hardened lead surrounded by an envelope of brass and steel. Its calibre is 8 millimetres (0·31 inch), its length 30 millimetres (1·18 inches), its weight 15 grammes (231 grains).

The **Russian Bullet** is ogival in shape, with a blunt extremity. It has an envelope of nickel, surrounding a nucleus of hardened lead. Calibre, 7·6 millimetres (0·3 inch); length, 30·5 millimetres (1·2 inches); weight, 13·70 grammes (211 grains).

The **English Bullet** is ogival, with a blunt apex and a casing of nickel. Calibre, 7·70 millimetres (0·3 inch); length, 31 millimetres (1·2 inches); weight, 15·90 grammes (215 grains).

The Belgian Bullet.—Ogival, with blunt apex, nucleus

of hardened lead, envelope of nickel. Calibre, 7·6 millimetres (0·3 inch); length, 30 millimetres (1·18 inches); weight, 14·10 grammes (213 grains).

The **Mitrailleuse** fires rifle bullets. Use is made of the infantry rifle cartridge. The multiplicity of the injuries inflicted, rather than their nature, distinguishes the mitrailleuse.

Ballistic Data (Bullets).

The military surgeon must be familiar with a certain number of ballistic data in order to understand, from a scientific and practical point of view, the effects of bullets. We shall content ourselves by recalling, and we hope without dryness, the essential data; but it is quite indispensable for him to *thoroughly* know what we are now going to set forth.

Velocity Transit.—A bullet has two kinds of velocity: a velocity of *transit*, by which the bullet passes through space; and a velocity of *rotation*, which sustains it during its trajectory.

The velocity of transit of a bullet is one of the principal factors of its active force (*vis viva*), or, in other words, of its power and of its effects.

The *initial velocity* of a bullet is expressed by the number of metres over which it would travel during the first second after leaving the muzzle, were it not subjected to gravity.

The remaining *velocity*, which is of far greater importance for us to know, is the velocity the bullet still has at the different distances of its trajectory. The “remaining” velocity decreases with the distance of the bullet from the muzzle of the rifle, owing to the force of gravity and the resistance of the air.

The *initial velocity* of the bullets now in use is considerable. The German bullet S has the greatest initial velocity, amounting to 860 metres, or 940·5 yards, which is 160 metres

(165·0 yards) superior to that of the French bullet D; but the latter, being heavier, retains its velocity better during the remainder of its course; it is thus still very dangerous at distances at which the S bullet is harmless.

The French bullet D possesses an *initial velocity* of 701 metres (767 yards); the M, or the bullet of the Lebel rifle, 651 metres (712 yards); the Russian, 643 metres (703 yards); the Austrian, 626 metres (684 yards); the English, 574 metres (628 yards, etc.).*

The remaining velocity is inversely proportional to the square of the diameter of the bullet and proportional to its length and its weight.

At 400 metres (437·4 yards) bullet S has 650 metres (710·8 yards) remaining velocity; bullet D has 536 metres (580·2 yards).

At 600 metres (656·2 yards) bullet S has 470 metres (514·0 yards) remaining velocity; bullet D has 470 metres (514·0 yards).

At 1,000 metres (1093·6 yards) bullet S has 301 metres (329·2 yards) remaining velocity; bullet D has 365 metres (399·2 yards).

At 2,000 metres (2187·2 yards) bullet S has 166 metres (181·5 yards) remaining velocity; bullet D has 210 metres (229·7 yards).

Velocity of Rotation.—To maintain the bullet on its trajectory, the grooves of the rifle impart to it a rotatory movement. The longer the projectile, the greater its movement of rotation; the latter, however, has but little influence upon the effect of the projectile; it remains constant for the same projectile.

Bascule Movements.—The S and D bullets are subject to *movements of oscillation* and of *deflection*, to which other projectiles are also subject, but in a slighter degree. Bullets may turn cross-wise or with their base in front;

* The English bullet has a muzzle velocity of 2,000 feet = 666·6 yards.

this may occur when they encounter a small obstacle in their course, or when they strike the human body. With bullet M, and also with the old German bullet, at 400 metres a fourth of such deflection has been noticed; at 600 metres one-third. These overturnings occur more frequently with the bullets S and D, a fact that the military surgeon must bear in mind, as well as the frequency of ricochets.

Trajectory. — The course followed by the bullet, its trajectory, was formerly represented by a long curve; the trajectory of modern bullets is straighter, and so increases the vulnerability of the object fired at, and also the extent of the dangerous space. The effect of the tension imparted to the bullet insures a more direct trajectory. Up to 500 metres the *trajectory* of modern bullets is *almost a straight line*.

Range. — The great speed of the bullets now in use enables them to attain a range of 3 kilometres, or more (3,800 metres—2·36 miles) in the case of bullet D.

Active Power (Vis Viva). — The damaging effects of bullets are dependent on their active power (*vis viva*). This is expressed by the formula $P = \frac{WV^2}{2}$, W being the weight and V the velocity of the projectile.

The following table represents in *kilogrammetres* the initial active power (*vis viva*) and the remaining velocity of the S bullet, of the Mannlicher, and of the French D bullet :

	Distances in Metres.											
	0	100	200	300	400	500	600	700	800	900	1,000	2,000
Germany	314	239	186	145	113	90	76	68	63	58	53	23
Austria ...	310	223	167	139	119	104	92	81	73	67	61	31
France ...	344	230	183	147	121	101	86	73	64	56	50	19

This table shows that the acting or damaging power is practically the same for the three projectiles; it is tremendous at 100 metres, considerable up to 500 metres.

From 500 to 1,000 metres the damaging power decreases rapidly; it is very small between 1,000 and 2,000 metres.

We thus understand why the classical works on army surgery, when dealing with the effects of bullets, are always careful to bring these effects within touch of the question of the distance at which the firing has taken place, and to speak of *very short* distances from 0 to 100 metres, *short* distances up to 500 metres, *middle* distances from 500 to 800 and 1,000 metres, *great* distances from 1,000 metres upwards. The greater the active power (*vis viva*), the more extensive are the injuries inflicted.

The *power of penetration* of a bullet is dependent on its active power (*vis viva*), on the extent of the surface on which it strikes, on its density of section—*i.e.*, the weight that prolongs backwards each unit of surface that is opposing resistance. This is the reserve of active molecules. A last condition that influences the penetrating force is the state of its surface of peripheral friction.

It follows from the above that the *pointed* S and D bullets have more power of penetration than the cylindro-ogival bullet with a flat apex; that the D bullet, being longer, has more power of penetration than the shorter S bullet; that a projectile that has ricocheted and struck sideways is less penetrating than one fired point-blank. *The resistance opposed by the tissues to penetration, of projectiles of equal speed, is inversely proportional to the square of the diameters.*

The bullet exercises on any obstacle it meets a more or less great pressure. The *coefficient of pressure* depends on the active power (*vis viva*) and on the calibre of the projectile. The smaller the calibre, the greater the pressure.

Ricochets.—Injuries inflicted by ricochetting bullets are very frequent. They are observed *in the proportion of 1 in 3 of all cases.*

A projectile ricochetting from the ground is deflected, and strikes the body obliquely or transversely. It is put

out of shape, flattened, turned out of its course, broken up, separated from its envelope, and so the number of injuries to which it gives rise is multiplied. To be put out of shape a leaden projectile must have a velocity of 450 metres, a bullet with an envelope a remaining velocity of 750 metres (Journée).

The S bullet, formed of hardened lead and covered by its envelope, is more easily put out of shape, flattened, and broken up on striking the ground, than the D bullet, which is made of brass.

Injuries inflicted by ricochetting projectiles are more serious than those caused by bullets fired point-blank.

Modus Operandi of Bullets.

Pointed bullets such as the S and D bullets make a puncture-like opening in the tissues when they reach them from a *point-blank discharge*. After penetrating, they *push the tissues aside, but without greatly bruising them*, thus creating very favourable conditions for spontaneous healing. Moreover, they *do not carry with them to any great extent foreign bodies derived from the clothes of the wounded man*. These are *essential* points to bear in mind.

When the S and D bullets have tipped over—when they have ricocheted in their course—they strike the body with a much enlarged irregular surface, and so exert strong *pressure* upon the tissues. Their mechanism then becomes *punch-like*, with a tearing and bruising action. Moreover, they *carry with them foreign bodies derived from the clothes, and may be soiled by contact with the earth*. These are points of paramount importance.

The greater the remaining velocity of the bullet and the more tearing its effects (bullets that have tipped or lost their shape), the greater the amount of active force it imparts to particles of tissue it separates. The fragments of tissue torn off play the part of *secondary* projectiles, which,

at first propelled in front of the bullet, whose track they prepare by slipping over its sides, transversely enlarge the track of the wound, giving rise to more or less bruising and disturbance.

The intensity of the action of the so-called secondary projectiles varies with the *velocity* of the bullet, its *shape*, the *nature of the tissues* with which it has come into contact, and with the *easy dissociation* of these last, and their *mobility*.

An *intense action* is chiefly observed with projectiles possessing *very great* or *great velocities*—that is to say, at short distances, varying from 0 to 100 up to 500 metres (*from 0 to 109 and to 547 yards (zone of so-called explosive effects)*).

With *pointed* projectiles, discharged at point-blank range, it is possible that the above-mentioned effects may no longer be seen. At all events, they occur more rarely than with conico-cylindrical bullets having a flat apex, or with bullets having a calibre of more than 8 millimetres (0·31 inch, Gras bullets). On the other hand, they are produced by the S and D bullets when these projectiles become deviated whilst proceeding at a high velocity. This has been observed over and over again in the present war.

Intense divulsive and propulsive action is exercised with greater facility the more the tissues are capable of dissociation, the less they show elasticity (muscles), and the freer the molecules (parenchymatous organs, brain). Incompressibility and their frequent projection explain the awful extension of the havoc that at times is wrought by bullets upon organic receptacles (bladder, intestines, stomach, gall-bladder). Not only may these receptacles present enormously enlarged apertures of exit, but they may also burst, and show large openings at some distance from the track pursued by the bullet.

The most elastic tissues of the body (tendons, fasciæ, aponeurosis), especially when they are movable (tendons of the wrist, of the instep), can transmit for some distance

the active force (*vis viva*) imparted by a bullet. Thus they bruise and split up the neighbouring and less resistant tissues (integuments, muscles). Fragments of bone detached by a bullet act like fragments of the projectile or like the bullet itself, forming a shower of secondary projectiles, which, from the centre of the injured limb, are propelled outwards through the soft tissues.

When the active power (*vis viva*) is of average strength (beyond the 500 metres, and up to the 1,000 metres range), the action of the bullet remains localized. The injury is of the nature of a *puncture* or an *abrasion*, with a weak projection, and more rarely with hard or soft secondary projectiles. Such is the usual normal type of the lesions.

When the active power (*vis viva*) is weak (beyond the range of 1,000 metres), the lesions are still more circumscribed; again, the bullet acts by *puncture*, and especially *separates* the fibres of the tissues.

The zones of the action of a bullet have been classed as follows :

1. *Explosive zones* (up to 500 metres).
2. *Perforation zones* (regular course, from 500 to 2,000 metres).
3. *Contusion zones* (beyond 2,000 metres).

Although the above classification has been criticized, it deserves to be maintained for bullets such as those of the Lebel rifle.

Projectiles of a calibre greater than 8 millimetres (0.311 inch), in addition to their divulsive effect, have a vibratory action which may be transmitted over a more or less considerable distance from the bullet's course, this vibratory action showing itself by phenomena of inhibition and of local or general shock. With pointed bullets fired point-blank, these phenomena are no longer observed. It may even happen that the wounded, even when their atten-

tion has not been taken off by the excitement of the battle, are unaware of the very serious injuries inflicted on them. The S and D bullets pass through the flame of a candle without causing it to flicker. On the contrary, when deflected, the S and D bullets frequently produce this shock.

The considerable active power (*vis viva*) possessed by the bullets now in use enables them to pass through several bodies, and *a fortiori* through more than one limb. The S bullet fired from a distance of 2,000 metres can still go through two men. The damage extends from the first to the last body or limb traversed by the projectile, if they are near to one another.

An active power (*vis viva*) of 8 kilogrammetres is sufficient to disable the combatant.

Contour wounds no longer occur with point-blank firing.

The So-called Humanitarian Bullets.—The modern S and D bullets cause a considerable immediate mortality, a fact often too little remembered by the surgeon who treats the wounded in the rear. The fortunate influence exercised by their pointed form and their small diameter is counter-balanced by the frequency of their turning over; this widens the bullet's track from its aperture of entry to its deep resting-place, and gives rise to contamination of the wound by the foreign bodies carried in by the bullet.

Therefore S and D projectiles are not humanitarian.

According to Journée, fatal injuries are in the ratio of 25 per cent., serious injuries 15 per cent., slight injuries 60 per cent. Generally, the same ratio is observable throughout.

If, in a certain measure, owing to their small calibre, to their pointed shape, and, as in the case of the D bullet, to their composition in a single piece, the present bullets give rise to a long series of slight traumatisms, whose very mildness, when the wounded are taken to the rear, strikes not only the surgeons, but also the general public, there is no

reason for bestowing upon them, and on some of those that have been used previously, the so abusively eulogistic German appellation of *humanitarian bullets*. The average of wounds, other than very small ones of the soft parts, remains grave; therefore we may repeat in regard to these bullets what we have said in speaking of the others: it is truly pushing the love for paradox very far to call *humanitarian* a bullet that goes through several men when fired from a short distance, and that is capable of causing great slaughter in a zone of more than 3,000 metres.

The adoption of bullets that, on meeting the slightest obstacle, turn on their axis, strike obliquely or transversely, giving rise to wounds that are often relatively of a large size, the making use of bullets that so easily turn over in the tissues and drive forward "foreign" bodies, certainly does not constitute progress from a humanitarian point of view.

The greater the velocity of the bullet, the more serious are the lesions, the graver the fractures of bone.

Other things being equal, the extent and severity of the injuries caused by rifle-fire depend on the active power (*vis viva*) of the bullet. But, far from the distance between the combatants being increased, it has remained unchanged; even it was noticed during the Balkan War, and has already been observed in the present war, the distance tends to decrease, and firing is carried on in zones in which the bullets acquire an excessive active power (*vis viva*), and the wounds they inflict are amongst the most dangerous known. In short-distance rifle-firing the *mortality is appalling*. The kind of madness soldiers feel in a charge (*furie française*) is heavily paid for, and charging would be most criminal were it useless.

To appreciate as a whole the gravity of the injuries inflicted by bullets, we must take into account not only those injuries the surgeon sees in patients brought to the

rear, but also the wounds that are treated at the front, the patients being subsequently removed to hospital, and the injuries seen on the battlefield in soldiers that have been killed. When all these data are united, instead of one only being kept in view, the impression with regard to the small bullets now in use, far from being favourable, becomes, on the contrary, unfavourable.

If all these injuries be taken as a whole, the pointed bullets now in use do not present any essential differences from the projectiles used in former times.

Explosive Bullets or Dum-Dum Bullets.—At the outbreak of every war there are always questions raised with regard to the employment of dum-dum bullets. It is so to-day. We have seen wounded men in the present campaign concerning whom this old error has been brought forward. The terrible injuries that have given rise to this mistake differ so greatly in character from those usually observed that it seems impossible to attribute them to the action of a bullet which causes but very small apertures of entry and of exit. This, however, is not so. In such cases it is a question of *explosive shots* due to projectiles of very high velocity becoming more or less broken up in their course through the tissues. The fury with which our soldiers have many times fallen on the enemy, and the fact of their being hit by bullets from very short distances, sufficiently account for these wounds that need no further explanation.

Systematic use of explosive bullets would show a want of common sense, because we rely on the effects of ricochettèd bullets, a ricochet occurring in the proportion of 1 in 3 of bullets discharged; besides, an explosive bullet can no longer hit a man if it has touched the ground, however slightly.



FIG. 2.—EFFECTS OF EXPLOSIVE FIRE (S BULLET).
(August 20, 1914.)

CHAPTER II

PROJECTILES FROM FIREARMS NOT CARRIED BY INFANTRY (GUNS)

THESE projectiles are those of *field, mountain, garrison, siege, naval, and coast guns*. Projectiles from garrison, siege, naval, and coast guns, being chiefly directed against armoured objects in defence or attack, are distinguished from the first by their massiveness and by the small tendency they have to divide. We will not stop to consider them. On the other hand, the two first-mentioned guns, mainly destined to be used against troops, will be minutely studied from the point of view of their construction, their ballistic qualities, and, lastly, of their effects.

Shells of Field Artillery.

As a general rule, shells from field guns are metallic cylinders of cast iron or steel, cylindro-conoidal in shape, with thick walls; the shell is subdivided into cavities which contain the bursting charge, and usually the projectiles.

The shell's anterior extremity, which is well strengthened, and is called the *ogive*, contains the fuse, which is separable, and is formed by an irregular mass of copper.

The shell's posterior extremity, which is also strengthened, and can often be separated, is called the *rear-piece*.

On the outer surface of the shell are the *forcing bands*, which can be detached; they are formed of copper rings,

of girdles of lead, of side-pieces, of nuts. Some howitzer shells are provided with discs.

The shell, when acted upon by the *time fuse*, explodes in the air; when acted upon by a *percussion fuse* it explodes on striking the ground. Some fuses have a double action, and are both time and percussion fuses.

Shells are designated according to their calibre: shell of 75, of 77, etc., or according to their mode of bursting: shells having a systematic mode of bursting, shells containing grape-shot (mitraille), shrapnel, explosive shells.

1. **Shells whose Bursting is Systematic** are projectiles with double-lined sides, showing lines of rupture, and breaking up into large fragments; others of the same kind have in the interior of their thick external envelope a number of piled up cast-iron rings, which break up into large and sharp fragments. These shells are but little employed.

2. **Shells containing Mitraille** have an outer shell containing metallic discs hollowed out into alveoli, for round bullets from 12 to 15 millimetres (0·47 to 0·59 inch). Segmentation, which takes place at the level of the alveoli, sets free fragments of cast iron irregularly cubic in shape and with sharp angles. Such is the present French mitraille shell.

3. **Shrapnel**.—The outer shell in this instance is thin; it rests in front upon a heavy ogive, at the back, upon a thick rear-piece. The interior of the shell is filled with free spherical bullets (10 to 16 millimetres, 0·39 to 0·63) of hardened lead. In some shrapnel the charge of powder is placed behind, by the rear-piece (Austria); great force is thus imparted to the bullets. In other cases the charge is placed in front; it then lessens the speed of the bullets, but facilitates their scattering. Lastly, the charge may be mixed with the bullets; this facilitates their scattering, and increases their power (French shells).

With this shell the ignition of the charge is secured by a

central tube. The French shrapnel of 75 centimetres contains 290 bullets of 12 grammes each (185 grains); the German shrapnel of 77 centimetres has 300 bullets of 10 grammes (154 grains) each.

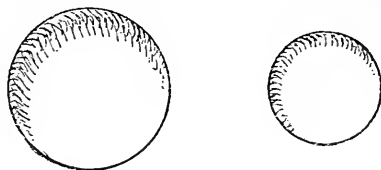


FIG. 3.—GERMAN SHRAPNEL BULLETS.
(Natural size.)

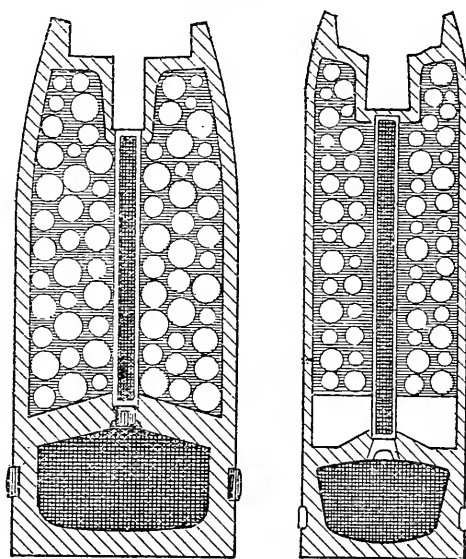


FIG. 4.—GERMAN SHRAPNEL.

The shrapnel of the German field-howitzer contains 500 bullets of 10 grammes each.

4. **Explosive Shells.** — Their moderately thick steel walls are hollowed out into a large cavity filled with an explosive material (gun-cotton, melinite, cresylite, etc.). The explosive shells are generally fired in the proportion of 1 to 3 by all artillery.

The variable quantity of explosive material contained in a shell has a very great influence on the effects produced. The German shell containing but 150 grammes (2,315 grains) of melinite is far less destructive than the French grape-shot shell, which contains 800 grammes (1·76 pounds) of the same material. From the outset of the war considerable difference has been observed between the injuries inflicted by German and French shells.

5. **Mixed Universal Shells** unite the characteristics of shrapnel and of explosive shells.

A *universal* shell with a double effect has been adopted by Germany for her field-gun 98 and for her howitzer 105. In its posterior part there is a powder-charge to project the bullets; in the centre are the bullets mixed up with a charge of powder. This central part of the shell is crossed by a tube which secures the ignition of the charge in the posterior portion of the shell. Finally, the ogive in front contains a strong charge of an explosive. The shell may be used as shrapnel with time fuse, causing deflagration of the charge behind, or as an explosive shell with percussion-fuse, with or without delay in the explosion after the contact shock, through detonation of the charge in front. Thus it may be easily understood that mixed shells which project shrapnel and sharp fragments of steel in the same way as an explosive shell may give rise to traumatisms of a special nature (Ferraton).

Case-shot are cylinders of sheet-zinc containing round leaden bullets held together by sulphur. When fired at a short range, these cylinders burst at once and scatter the leaden bullets; these are analogous to shrapnel bullets, although heavier (40 grammes, or 617 grains, France). Great use was made of these projectiles during the attack on Liège.

Grenades are explosive bombs thrown by hand; they are spherical in shape and loaded with explosives. The grenade

is often an improvised bomb containing projectiles of every shape and weight. The effect produced by its fragments varies greatly, terrible in general at a short distance. Its action is quickly exhausted. The explosive action of the gases is exerted over only a small area, in which, however, it produces great havoc.

Ballistic Data concerning Shells.

Following the method adopted in describing bullets, we shall now only consider the data that are of interest to the military surgeon.

It may be said that shells only act through their splinters or their bullets.

In the case of the *ordinary shell* with cast-iron walls, the large fragments are almost exclusively supplied by the rear-piece, the ogive, and the fuse. Fragments of *average size* weigh from 100 to 300 grammes (1,543 to 4,630 grains); *small splinters* are about the size of a walnut. The present steel shells eject from their entire periphery small elongated splinters, not very thick, about 1 or $1\frac{1}{2}$ centimetres (0.39 or 0.59 inch), sometimes they are as large as a pea; their dimension, however, may even be that of a small fragment.

Fragments of these shells rapidly lose their velocity. The slightest obstacle—a clod of earth, a helmet, a haversack, etc.—may serve as a protection from them. The Serbians use the shovels with which entrenchments are being made; the Bulgarians use earth; the French soldier his knapsack, which protects his head and shoulders, whilst leaving his hands perfectly free.

The French *mitraille shell* discharges 416 bullets of 25 grammes (386 grains), besides 288 disc fragments, weighing on an average 40 grammes (617 grains).

The larger fragments of *shrapnel* are supplied by the ogive and the rear-part.

The principal projectiles of shrapnel are *round bullets*, from 10 to 15 millimetres (0·39 to 0·59 inch) in diameter, of small weight, and low velocity; *they may be compared to the old smooth-bore bullets.*

They inflict, in general, slight injuries, such as contusions or incomplete perforations, the projectile remaining in the wound, rather than through-and-through perforations, and their “cul-de-sac” wounds are often complicated by the presence of foreign bodies derived from the soldier’s clothes, which favour suppuration.

Fragments from the much sub-divided wall of an *explosive shell* are usually broken up into small, thin, striated and sharp lamellæ; nevertheless, some of them spread out and act like a badly sharpened knife. These fragments are very small, and sometimes become localized in the body as if they had been sown like seed.

Most frequently the shell explodes in the air (time fuse) at more or less distance above the combatants. The distance separating the shell from the ground is called *bursting height*. When this height is small, the shower of fragments or bullets is dense, that is to say, closely charged with projectiles, and the velocity of these secondary projectiles is increased; the shell then is very deadly. It would appear that it is of very little use when the bursting height is great, the shower of projectiles is then more spread out, less dense, more apt to produce wounds, but dangerous effects upon the human body are less conspicuous.

The shell with *percussion fuse*, which is rarely used, must strike the ground before exploding. When it falls perpendicularly, it either buries itself in the earth or forms a funnel-like excavation, in which its fragments are retained. If it strikes the ground obliquely, it rebounds, gives off a shower of projectiles, the marks of which are shown on the ground as an elongated ellipse. The splinters and the bullets close to the bursting-point have a greater penetrating

force than those from a greater distance. In general, these last are the ones that cause wounds.

The *velocity* of the fragments and of the bullets at the point of explosion is that of the shell at the time of falling. The velocity is—

At 1,000 metres : 422 metres, French shell ; 369 metres, German shell.

At 2,000 metres : 346 metres, French shell ; 310 metres, German shell.

At 3,000 metres : 300 metres, French shell ; 279 metres, German shell.

In the case of the time-fuse shell, this velocity is increased by the active power (*vis viva*), communicated by the charge in the interior. With the percussion-fuse shell, the bullet has to travel over several hundred metres before reaching the body ; and during its course in the air, owing to its shape and size, it undergoes great loss of velocity.

Whether the bullets or splinters proceed from a shell with a percussion fuse or from a shell with a time fuse, when they penetrate into the tissues the large rounded shape of the former, the spread out and irregular shape of the latter, considerably limit the power of penetration, as the *resistance of the tissues is proportional to the square of the diameters of the projectiles*.

Consequently, one may say that these bullets or splinters do not possess half the penetrating power of rifle bullets.

Explosive shells directed against obstacles, but which reach the defending troops, are commonly and deliberately used at the present time against the enemy. These explosion shells, as well as the ordinary percussion shells, under certain circumstances, may loosen and hurl about stones and débris that play the part of accessory projectiles.

Explosive shells are often productive of multiple wounds. Six, seven, ten, and more, have been observed in one wounded man.

CHAPTER III

WOUNDS OF DIFFERENT TISSUES

THE injuries inflicted by bullets on the soft parts are very frequent. This frequency is a factor of great importance to the army surgeon, who has to take it into consideration in the preparation and distribution of dressings when arranging for transport, and making a computation of invalided men and of those who return to duty.

The percentage of the injuries of the soft parts is estimated at about 45 or 50. The percentage even rose to 80 during the American War. Fischer stops at 65 per cent.

Injuries of the Soft Parts due to Bullets.

We will first study the injuries caused by rifle bullets. The division here adopted should be maintained in statistics.

Contusions.—These are produced by spent bullets or tangential firing, frequently also caused by bullets from a shell. Contusions may be very slight, or they may end in sloughing.

Erosions, Furrows, result from tangential rifle fire—small *scratches*—at the level of which the skin dries up and becomes covered with a brownish pellicle; no cicatricial trace is then present. Sometimes these are *cutaneous abrasions* more or less extensive, occasionally 5, 6, or 7 centimetres long and 2 or 3 centimetres wide, owing to the

retraction of the skin, showing regular or contused perpendicular edges. Their deeper part is formed of cellular or muscular tissue; they leave cicatrices.

Cul-de-sac Wounds are due to the action of bullets of low velocity which have frequently ricocheted. They leave a blind track more or less deep, generally containing the projectile that has caused the wound. When the track is short, the bullet may have been displaced by some movement or by the removal of the clothes.

The cutaneous aperture of entry is generally of less dimensions than the diameter of the projectile—it is perfectly round or oblique; on the contrary, it is large and irregular when caused by a bullet that has been deflected before striking the body.

Setons are perforations that go through and through. We will now study their *apertures* and *track*.

The *aperture of entry* varies in aspect: sometimes it is rounded, circular (in point-blank fire), with an apparent diameter much smaller than that of the projectile; there is loss of substance. On other occasions, especially with pointed bullets, it is punctiform, and so narrow that it is difficult to identify it. It has been compared to a flea-bite. More often than not it is soiled by the projectile that in passing has rubbed off against it the impurities gathered during its course; the epidermis has been destroyed, and the derma bruised around the apertures. At times it is contaminated by shreds of clothing that have penetrated farther than its edges. As to its dimensions, they vary, in general, with the velocity of the bullet. They are a little larger with short distances, a little smaller with middle, and insignificant with long ranges. They are also larger when the integument lies on a resistant plane, and smaller when the skin can be depressed. When the bullet strikes obliquely, the aperture of entry is increased in size, oval or elliptical in shape, with bruised edges.

The tension of the tissues, the position of the limb, the direction of the cutaneous folds, may modify its shape.

The *aperture of exit* is nearly always irregular, and shows in the form of a cleft, which may be either simple or radiated, and is sometimes circular and punctiform. It appears larger than the aperture of entry, but in reality it is smaller, as it is probable that the skin has been much distended before being perforated. Now and then its edges are everted, and not bruised like those of the aperture of entry. The dimensions are commonly, although not regularly, proportional to the velocity of the bullet—that is to say, inversely proportional to the distance of the firing.

Under the loosened integument a little pouch filled with blood sometimes forms Pirogoff's pouch.

Track.—In the great majority of cases the track may be represented by a straight line uniting the apertures of entry and of exit, always supposing the limb or the trunk to be in the same position as at the time when hit by the bullet.

The *laminae or accumulations of cellular tissue* that the bullet meets with are, according to the velocity of the projectile and to their nature, freely perforated (*laminae*), or only dissociated (*accumulations*); the paniculate masses of adjoining adipose tissue then fill up where there has been a loss of substance, thus forming an aseptic occlusion.

Superficial fasciæ are wounded, and present circular or oblique apertures, when the velocity of the bullet is great; but with average or low rates of velocity, only the transversal or uniting fibres are dissociated. The longitudinal fibres become forced apart, and, as we have before demonstrated (and the fact carries very great interest), *the wound is no longer represented by a loss of substance, but by what resembles an incision, a sort of button-hole-like slit with reunited edges*. These aponeurotic button-holes secure the occlusion of the track.

In *muscles* the track is always cylindrical, widened in the

living by muscular contraction, filled up with blood, exudation, and inflammatory swelling. The track is larger than the diameter of the projectile. Its size varies with the velocity of the bullet, as is the case with other tissues. In close-range firing the track is much larger than in middle ranges, and still more than in long ranges. Tracks in muscles are narrower when the bullet is pointed than when its apex is flattened; the fissures they cause are typical when the firing is point-blank.

When the track follows the direction of the muscular fibres, it is not an easy matter to find its course on the dead body (Ferraton).

By reason of their mobility, their elasticity, their shape, and of their being made up of linear fibres, *tendons* are, of all tissues, the ones that offer the most successful resistance to the action of the bullets. Being loose in their sheath, they are displaced and eroded; if they are more or less fixed, they are indented and lineally perforated.

Exceptionally they are completely divided, but it is doubtful whether this can occur with pointed bullets. This question must be further studied at autopsies. To sum up, the track modern bullets make in the soft parts, as it was with the old bullets, is irregularly cylindrical. It shows constrictions at the level of the linear aponeurotic slits, and even irregularities at the level of the thick cellular layers, and of the tendons that have only been displaced. It is filled with a magma of broken-down soft tissues and with blood. Infiltrations of blood and histological fissuration have been noticed a few millimetres, even a few centimetres, from the course followed by the bullet.

Theoretically, when the velocity of the bullet is very great, the dimensions of the track should increase as it approaches the aperture of exit; but the layers of aponeurosis generally resist the divulsive and progressive action of the projected particles of tissue by arresting them on their passage.

The track is more especially enlarged in the case of bullets that have tipped up and have remained in the tissues. It is still more enlarged, but in this case from one end to the other, when the bullet has ricocheted on the ground before reaching the injured part, or when it strikes obliquely or sideways. When deflected in the midst of the tissues its track is irregular.

Enfilade Wounds.—Certain tracks are greatly extended when the firing is from above downwards or from below upwards, as in cases in which hills, buildings, or houses are attacked. One frequently sees that a bullet under these circumstances has pierced for itself a course from the neck to the buttocks, from the hip-joint to the lower part of the leg, etc. Under normal conditions of firing one finds that the bullet may have travelled a considerable distance through different segments of the same upper limb, forearm, axilla, etc. The prone horizontal position that is frequently assumed by the infantry soldier in the intervals during the rapid advances that bring him nearer to the enemy renders his body liable to be wounded over a lengthy extent, and explains why, even under ordinary conditions, enfilade wounds have become very frequent.

A great many tracks are *multiple*, either caused by several projectiles, by fragments of bullets broken up by having ricocheted near the wounded man, or by the same bullet having successively perforated two different parts of the body—arm and thorax, arm and forearm, both right and left thigh, etc. We must bear in mind when the velocity of the bullet is very great, the second track is often larger than the first.

When the soft tissues are the only ones involved, no explosive lesions are observed from pointed bullets fired at short range. Nevertheless they may occur, especially in tendinous regions.

Wounds of the soft tissues, inflicted by projectiles from

modern rifles, are not painful; many of them *bleed* sufficiently to stain the clothing.

Wounds from Revolver Shots.—They are analogous to the injuries of rifle bullets. The apertures and tracks are narrow; no explosive effects are noticed in their case. The projectile often remains in the wound.

Injuries inflicted by Bullets from Shells and by Small Shell Splinters.—The round balls from shrapnel, like rifle bullets, cause simple contusions, cul-de-sac wounds and setons, which may be compared with the wounds from rifle bullets; the description of the former, therefore, may refer also to the latter. Contusions are very frequent, as also cul-de-sac wounds, in which the bullet and foreign bodies derived from the clothes remain in the wound.

Cul-de-sac wounds are usually pretty superficial; their apertures and track, like those of the setons, are larger and more gaping than is the case with rifle bullets. They resemble the bullet wounds of old times. *The wide gaping of these wounds and the presence of foreign bodies, chiefly derived from the clothes, tend to facilitate their infection.*

Evolution and Progress of Wounds of the Soft Tissues.—Most wounds of the soft tissues *by rifle bullets* heal by first intention, without a trace of suppuration, or else with a slight and passing secretion from the contused cutaneous aperture of entry. These wounds are quickly covered by a small protecting darkish scab, due to the drying up of the blood-clot, under which cicatrization takes place. Our modern methods of dressing powerfully contribute to this healing; but as it was observed to take place even before the adoption of modern methods of treatment, and as at present it is frequently noticed in patients in whose case treatment by a surgeon has been impossible, or who have even been badly dressed, we are forced to admit that other reasons must be brought forward to explain so favourable a result. At one time it might be considered

due to surgeons having abandoned septic and frequent explorations of the wound ; but to-day it is attributed to *the ever-increasing narrowness of the wounds*, in consequence of the small diameter and of the shape of the bullet, to the *extremely slight gaping of the wound*, to the *much less frequent presence of foreign bodies*, and, above all, to a fact upon which we have dwelt again and again—*the occlusion of the track at the level of the aponeurotic septa*.

Long discussions have taken place on the *primary and direct contamination of the wound* by the bullet and the dirt with which the projectile may be coated, by the shreds and pieces of clothing which it may carry with it ; also on *indirect contamination* by contact with the wearing apparel, with the patient's fingers, or with the fingers of those of his comrades who may have administered first aid. To-day the problem is solved. To sum up, the germs carried along by a bullet are not pathogenic, and the bullet itself does not infect ; the contamination brought by the clothing is annihilated by the defence set up by the tissues. Besides, a wound infected by a bullet, especially by a pointed bullet, having an average velocity, fired point-blank, carrying with it no large foreign bodies derived from clothing, is in the very best condition for spontaneous healing. Dressing but affords a fresh guarantee to a natural tendency towards cicatrization.

Aseptic evolution is frequent, especially in cases of narrow wounds ; but large wounds, such as those resulting from a bullet that has been deflected by touching the ground, wounds soiled or contaminated by large pieces of clothing, wounds that have remained a long time in contact with clothing, or that have been badly dressed and badly looked after, are *all subject to suppuration, and therefore must be carefully watched*. The evolution of such wounds will then be either *relatively aseptic* or *decidedly septic*.

In the first case there will be slight suppuration of the

cutaneous apertures and of the track. Slight, but not painful, swelling of the soft tissues will be noticed at first; next, a slightly indurated cord-like feeling will be found along the track, after which the natural condition will be re-established; the muscles will recover their suppleness, healing will take place without consecutive disturbance. Such is *an ordinary course* of wounds resulting from infected bullets, but these wounds must have been watched and treated by capable surgeons, having a good armamentarium, in good sanitary quarters, and provided the wounded men present normal organic resistance.

In the second case—and the condition is customary in wounds due to shrapnel bullets, to shell splinters, to bullets deflected by contact with the ground, or in wounds badly dressed, and whose apertures are plugged by some foreign body—suppuration takes place. It is more or less abundant, sometimes foetid; it is accompanied by tension and redness of the limb; the pus extends and burrows. Certain cases develop a diffuse phlegmon.

Wounds inflicted by shrapnel or by small shell splinters, generally show rapid formation of pus, with more or less intense local reaction, which usually quickly yields to antiseptics at the seat of the mischief, to free incision, and to removal of foreign bodies, either metallic, or composed of pieces of clothing.

To recapitulate: *From a general and practical point of view, the wound by a rifle bullet may be considered as aseptic.*

Many of these wounds become infected and threaten suppuration. The greater number heal naturally.

Healing takes place in a few days or weeks.

Wounds by shrapnel or by small shell splinters USUALLY SUPPURATE.

Very large and extensive wounds that are lacerated, bruised, and frequently very dirty, and result from large fragments of shell, the lesion containing or not containing the

body that has caused the mischief, ARE HOPELESSLY DOOMED TO SUPPURATION. Healing is obtained after elimination of the scabs and when the wound has granulated. Local and general phenomena of reaction, sometimes very intense, subside rapidly if the wound is dressed with a solution of hydrogen peroxide. When the wound has been cleaned, its size may be reduced by means of careful bandaging, or by means of U-shaped mediate sutures.

Treatment.—The first treatment of bullet wounds in the soft tissues consists in carrying out the indications that Ferraton has so well recapitulated :

1. *Do not touch the apertures.*
2. *Do not explore the wound.*
3. *Carry out the dry toilet of the skin by means of an aseptic swab which may be wrung out in alcohol or in tincture of iodine.*

4. *Apply the ordinary dressings.*

Occlusion of the apertures, suturing, incisions to relieve constriction in the wound, must all be avoided.

For first aid to bullet wounds the dressings contained in the packet each soldier carries will suffice. As a rule the first dressing should be applied at the part of the field where the man has been wounded, or at the first aid station.

Individual Dressing-Packet carried by the French Soldier.—These packets are of various patterns. The old pattern has two wrappers of ordinary canvas, then a waterproof covering, partly tacked together, partly stuck together, which protects the contents from external impurities and from humidity.

Each packet contains (1) a square piece of gauze ; (2) a square piece of purified tow surrounded by gauze ; (3) a cotton bandage ; (4) two safety-pins.

The gauze and the tow are antiseptic ; they are impregnated with bichloride of mercury.

Events have not allowed us to completely replace the old

packets by the new model, which differs from the former one—

1. In the solidarity of the different pieces.
2. It guarantees the dressing of two wounds at a distance from one another.
3. It is aseptic.

The contents of the new model are wrapped in Japanese paper, which is strong, waterproof, and at the same time very light.

The packet is opened by pulling on a small linen tape which projects from one of its corners.

It contains *two* dressings ; each consists of a pad of hydrophyllous cotton-wool enveloped in gauze. One of these dressings is fixed, being sewn to the linen bandage destined to bind up the wounded limb ; the other is movable, and slides along the bandage by means of two tapes.

The materials forming this second dressing have been sterilized in the autoclave, and render unnecessary the use of an antiseptic.

The solidarity of the various parts forming the dressing facilitates its application and diminishes its risks of being contaminated. In order to better insure it against contamination, two distinct signs (a red cross and a black cross, surrounded by a circle) mark the places where the dressing should be taken up, one sign for the right hand and one for the left. To displace the movable dressing without soiling it, a little red tag will be found sewn on one of its corners by which it should be held.

It is impossible for us to lay too much stress on the fact that the individual dressing is “a reserve supply of material for ready use carried by the wounded.” As a general rule the dressing should not be applied by the wounded man himself, nor by his comrades, nor by a N.C.O. ; it should be applied by a medical man, or by a trained member of the Army Medical Service. This is undisputable ; it is

better not to dress a wound at all than to dress it badly, and it is as well to look upon with suspicion, and as necessitating a fresh application, any dressing that has not been carried out by a competent person (H. Billet). The necessity of a preliminary disinfection of the skin renders a new dressing imperative.

Dressings must be directly applied to the skin, the clothes having been *unstitched* or *cut open* into strips so as to expose the wound and its surrounding parts; this should be the exclusive duty of a surgical attendant. Another attendant should open the packets containing the dressings. The man who dresses the wound should first carefully disinfect his hands; washing the hands with soap is less practical than immersing them during three minutes in alcohol at 90°, or, if necessary, in methylated spirit, containing per litre 5 c.c. of 1 in 10 tincture of iodine (the whole solution being 1 in 2,000).

When we wish to disinfect the circumference of the wound with iodine—an excellent plan, and one which is held in high esteem in the surgical practice of all armies—the above application should be made *dry*, without previous cleansing with soap, water, alcohol, or ether, etc. *One single coating with iodine will suffice.* More than one layer would be useless, or might even be injurious. Friction of any kind should be avoided.

For the cheeks, the eyelids, or the genital organs, diluted tincture of iodine should be used; for all other regions of the body the pure tincture should be employed. Accidents, brought about occasionally by tincture of iodine, such as erythema, vesication, excoriation, or ulceration, are chiefly due to the applications having been made over too extensive a surface or too plentifully, to frictions having been carried out, or to antiseptic reaction, but also to the use of tincture of iodine that age has rendered stale.

The medical staff is now provided with unalterable tinc-

ture of iodine (Courtot), of easy transport, thanks to its having been compressed (Pellerin). The compressed tincture is instantly dissolved in alcohol at 95°, each block being made up so as to give a solution of 1 in 20, which is not caustic.

Robert and Carrière have enclosed sublimated iodine in glass ampullæ. When required, the ampulla is broken, its contents poured into an accompanying tube containing alcohol at 95° in sufficient quantity to obtain tincture of iodine.

Tincture of iodine is at present the best and safest disinfectant to make use of in the practice of war surgery, both in the fighting line and in the rear.

Bichloride of mercury and carbolic acid, with which the individual packets of the old pattern were impregnated, like most of the individual dressings in use in different armies, render the patient liable, when tincture of iodine is used—an antiseptic to which preference is given nowadays for first aid treatment of a wound—to symptoms of irritation, which are but rarely observed with a simple aseptic dressing.

In the Manchurian campaign these symptoms of irritation were so pronounced that the Russians and the Japanese who made use of bichloride of mercury dressings were obliged to give up tincture of iodine for the disinfection of wounds.

We have been able to verify on wounded men in the present war the cutaneous irritation pointed out by the Russian surgeons. The difficulty might be overcome and these untoward incidents avoided by first of all applying under the dressing a little square of folded gauze; this should be done at the collecting and first aid stations. The first dressing of the wound will generally be held in place by the bandage contained in the packet. An extra bandage will make the dressing more secure.

In the ambulances in the rear, where the dressing has lost

the fixity it had at the front, the use of adhesive rubber spardrap, of the leucoplastic or vulvoplastic type, has been advised. Personally, we have not been satisfied with the results we have seen of this method.

There are counter-indications to repeated dressing of wounds of the soft parts produced by bullets; these lesions are very slight, and already present conditions most favourable for spontaneous healing.

We have already seen that wounds by ricochetted bullets are subject to symptoms of suppuration coming on very rapidly. After incisions have been made dressings will be applied of the usual topical remedies. Hydrogen peroxide here is particularly worthy of recommendation for the first consecutive dressing. Strong carbolic acid solutions, touching the wound with a 1 in 10 solution of chloride of zinc, iodine by instillation, or by simple application, instillations of ether, etc., are all of great use. We must not forget that these wounds are often *complicated by foreign bodies derived from the clothes*, or by the presence of the bullet itself; in such cases *the only topic to be employed is hydrogen peroxide*.

The wounds we are now considering are among those in which there is always a danger of tetanus and of emphysematous gangrene; hydrogen peroxide is known to be a toxic for anaërobic microbes, which are the provocative agents of these complications.

The same principles should be followed and the same methods applied in dressing extensive wounds of the soft tissues resulting from shrapnel or shell fragments. We will not dwell upon this subject at present, as we shall have to consider it again in dealing with complications.

CHAPTER IV

LESIONS OF THE VESSELS

Wounds of Arteries.

JUDGING from the medical history of warfare, wounds of the large vessels are rare ; but, on the other hand, post-mortem examination has shown that they are very frequent (Delorme, Chauvel, Fessler). Their extremely serious nature is the explanation of the rarity of cases which have been observed and subsequently published. There are new and precise data to be contributed with regard to their total as well as their relative ratio.

With the Gras and Lebel bullets, in the great majority of cases, when the projectile encountered arteries in its course, it either broke through them or bruised them. Their elasticity, their mobility, the fluid nature of their contents, hardly ever allowed them to escape from the action of the bullet. It was the same with the G bullet during the Balkan War.

The lesions seen in arteries are—Contusions, lateral wounds, perforations, and section.

Contusions.—They are reported less exceptionally than wounds, because overwhelming hæmorrhage is not here a fatal consequence.

Three degrees of contusions may be noted :

In the *first degree* the artery is ecchymosed on its surface, and in its interior it exhibits slight fine transverse lacera-

tions, which look as if they had been produced by the point of a pin. These solutions of continuity correspond to the horizontal interstices in the muscular and elastic fasciculi of the middle coat of the artery. The contusion is therefore represented by a series of internal wounds.

If the middle coat is deeply and transversely fissured at points corresponding to where the bullet has passed—if it shows what is really an internal wound which is localized and irregular—then we have the *second degree*.

In the *third degree* there are deep lesions exhibiting the same characteristics; however, they are no longer localized, but extend over the whole lumen of the vessel. The outside of the artery is more ecchymosed, and the vessel is narrowed at the wounded part.

Knowledge of these facts is very important. If, strictly speaking, in the first degree the formation of an obliterating clot is not fatal (Matthew), the same thing is certain to occur in the two last, and the friction to which the arterial wall has been exposed renders it liable to gangrene. Yet in the last degree the complete rolling up of the inner coats makes the clot much firmer than in the second degree.

These contusions therefore can, especially in aseptic wounds, be of no consequence (first degree); they may cause *obliteration of the artery*, local ischæmia, and disappearance of the pulse of the vessel; they may be followed by the formation of a scab, especially in septic wounds; or they may be followed by consecutive terrible hæmorrhages; and, lastly, they may give rise to the formation of an aneurysm.

There are no characteristic features in the troubles of sensation and of motility caused by arterial contusion; there is strong probability of gangrene occurring at a distance; the *only* sign of real value is derived from—

1. *The close relationship the course of the bullet assumes with the artery.*

2. *The disappearance of the arterial pulse when there has not been any considerable primary hæmorrhage, and no aneurysm has been noticed.*

These signs are valuable, because they can be looked for at once. A wounded man who is suspected of suffering from a contusion of a large artery *should not be moved.*

He must be closely watched. His fate depends partly on asepsis, partly on a septic condition of the wound, bringing about the falling off of the scab.

It is prudent, if one has any doubt concerning the asepsis of the wound, to search for the vessel without waiting for the occurrence of hæmorrhage; and if it is found to be much ecchymosed, and especially if it is narrowed, to ligature it both above and below the contused part.

Would incision into the artery, turning out the clot and suture of the vessel, be of any use? (This operation has been proposed.) After ablation of the clot, however, another one would recur in the same place through contact with the internal irregularities of the arterial wall, and, furthermore, suture of the contused wall certainly would not hold.

Lateral Wounds.—These consist of loss of substance of a curved shape, which may involve a quarter, a third of the transverse diameter of the vessel. The indentation is clean, sometimes it has fissures on its margins. All the arterial tunics are divided on the same level, and the middle coat is not retracted.

Very superficial and slight scratches, but with no opening into the artery, have been described. When the wound has involved nearly the whole of the diameter of the artery, owing to movements of the injured limb, the vessel may burst; this may be regarded as a fortunate circumstance.

Complete Perforation.—Through and through perforations, as well as lateral perforations, are often described in post-mortem examinations. They are circular or nearly

oval, exceptionally linear with the Gras bullets and the Lebel bullet, which last is analogous to the Austrian Mannlicher and the German Mauser bullets. With pointed projectiles will linear wounds become less exceptional? This is a matter to investigate.

The edges are clean, scarcely fimbriated; both above and below the lesion the internal tunics are not retracted.

The dimensions of the apertures are small or the contrary according to the greater or less velocity of the projectile. They are still smaller, with a pointed bullet of small diameter. As a general rule, both the walls of the artery are perforated.

Those *gaping* wounds, the spontaneous plugging of which was impossible, gave rise in former times to awful external hæmorrhage; the blood poured freely from wounds with large external orifices. Now that these last contract, external bleeding is less fatal and less abundant; *primary false aneurysms are more often seen, and they constitute a fortunate termination.*

Complete Division.—This is more especially noticed in small arteries. In the larger vessels it seems to be caused by the action of bullets having a very high velocity. Deflected bullets and those from shrapnel very often produce it. *A priori*, these wounds would seem to be very grave; in reality they are not so, for the transverse tearing, the shreds and strips of the middle coat, the fraying out of the external coat at the two ends where the division has occurred, promote the formation of clots in the same way as the total narrowing of the walls is consecutive to retraction of the two segments of the vessel.*

* During the Balkan War it was observed that at short distances, clear loss of substance of the artery, with hæmorrhage, took place; at average distances there occurred lateral wounds, more frequently perforations, more rarely simple contusions, complete sections, the vessel being often contused and reduced to pulp, tearing of the artery when the bullet came from a cross direction; at long distances there were principally contusions.—FERRATON.

Wounds of arteries the results of the *bursting of shells* present the characteristics of lesions caused by tearing, by direct contusion, by lateral perforation or section (sharp-pointed or linear fragments). Small shell splinters might produce linear perforation. Shrapnel bullets generally give rise to contusions of arteries, and less frequently to perforation and section.

When a limb is torn off by large projectiles or their big fragments, the vessel, besides being divided, is drawn out for some distance. Thus can be explained the absence of bleeding, in spite of the gaping of the large arteries.

Arterial wounds caused by splinters thrown out by the bursting of a shell are beyond all description.

The close relations of the large arteries to the large veins are the cause of both vessels being often wounded at the same time.

SYMPTOMATOLOGY — PROGNOSIS. — Everyone knows the fundamental signs of wounds of arteries: *hæmorrhage* nearly always in jets; the bright colour of the blood. *This bleeding may be stopped by proximal pressure; cessation of the pulse on the distal side of the vessel.*

The concomitance of arterial and venous wounds rather mars the clearness of this description. *Hæmorrhage* with narrow wounds often becomes *hæmatoma*, but this last brings with it a new sign—*its pulsation*.

External *hæmorrhage*, in contradistinction to what one would suppose, is not always of great importance when large vessels are affected. Amongst twelve cases of lesions of large vessels Hildebrandt and Kuttner only found abundant *hæmorrhage* six times, whilst there were five insignificant *hæmorrhages* and one average bleeding. These are ambulance reports which really only deal with a part of the reality. Wounded men with grave *hæmorrhage* succumb before arriving at the ambulance station if their external wounds are extensive.

A fact, the result of the experience acquired in recent wars, is that, by reason of the narrowness of the track made by the present bullets, and of the antiseptis or asepsis of the wounds, the prognosis of the lesions of the large vessels has been improved, *a little, a very little*, without, however, having become much less unfavourable. It is specially the prognosis of wounds of average-sized vessels that has been modified.

TREATMENT.—I. On the field of battle, at the receiving and first aid stations, indirect *digital compression*, followed at once by *indirect mechanical compression*, are the first methods to employ.

Indirect digital compression still retains its superiority for wounds of the carotid and of the subclavian.

Morel's *garrot* and Mayor's *cravat bandage** (cravat with a knot which is applied to the course of the artery) are the best means of applying indirect mechanical compression. They only show to disadvantage when their use is prolonged, which is quite contrary to their purpose. They should be employed almost as makeshifts, their *application being only temporary*.

Forced extension or flexion of the limbs is helpful and useful. In certain large wounds the surgeon may utilize aseptic plugging. This, however, is disadvantageous if left in too long, and if the wounded man is lost sight of (Russo-Japanese and Balkan Wars).

If the wounded man arrives at the ambulance station fixed up in some apparatus, or in one that it is possible to fix, *he should remain in it*. Whatever the future treatment decided upon, *the patient must not be transported*. Transport renders the clots liable to displacement, and removes the wounded man from direct supervision.

Soldiers wounded in the chest during the Transvaal War

* This is probably a modification of Mayor's handkerchief dressing for fractured clavicle.—*Note by Translator.*

were attacked with internal hæmorrhage and hæmothorax in the proportion of 90 per cent. when they were transported from one locality to another, and in the proportion of 30 per cent. when they were kept at one place (Makins).

Whatever the treatment made use of, it should be employed when possible before the patient has recovered from his condition of syncope, or at any rate whilst he is recovering.

The first indications of the so-called definite treatment should be settled at the ambulance. They are transcribed from, and explained in, the following lines taken from my communication to the Academy, February 24, 1914:

“For a long time the practice of war surgery in cases of wounds of the large arteries has been reduced to the two following formulæ:

“1. The opening into a large artery necessitates, as *immediate treatment*, *compression* in the interval before the application of a *direct double ligature*, that is to say, one that is carried both over and under the lesion. This ligature was looked upon as an *operation of urgency*.

“If the hæmorrhage has ceased when the surgeon sees the wounded man, he can either wait, keeping the patient under close observation, or apply a direct ligature if he fears a recurrence of the hæmorrhage.

“This was the rule; its carrying out had to take the risks which might be set up by the surroundings of the case. In fact, immediate or rapid ligatures of the large vessels could be counted by units in the histories of campaigns, and in spite of the large number of well-known and much-talked-of extemporary compressors, first aid hardly ever arrived in time. Deaths through hæmorrhage, on or close to the field of battle, reached the enormous proportions that are well known; the blood so easily escaped through the relatively large wounds made by bullets and through still larger orifices left by shells.

“The suppuration that invaded these wounds, whilst

giving rise to the displacement or the softening of the clot, and, in contusions of arteries, to the separation of the scab, and, finally, to various other infections, consecutively increased the number of deaths through hæmorrhage. Cases of aneurysm were very rare. I had a great deal of trouble to find, for my *Treatise on War Surgery*, the number of cases of aneurysm that satisfied me. Otis, during the American Civil War, amongst several hundred thousand cases, only observed seventy-four; and Pirogoff, that veteran of Russian campaigns, tells us that he never saw an arterio-venous aneurysm the result of a projectile.

“First aid has been better understood of late years, but of more importance still are certain characteristics of the wounds brought about by modern bullets, and also, we are bound to say, the more rapid and more simple healing of the external lesions, all these have caused, in this terrible prognosis of wounds of the large vessels, a mitigation that began to be noticed by surgeons during the Transvaal War, and which continued to make an impression on medical men during the Manchurian and Balkan campaigns. The nature of the arterial and venous traumatisms was the same: *contusions, indentations or lateral perforations, central perforations with a piece, as it were, punched out*, that have been described by Lidell and me; but where the greatest change occurred was in the narrowness of the course the bullet made in the thickness of the soft parts—this facilitated spontaneous hæmostasis.

“Speaking generally, the number of cases of profuse external hæmorrhage has diminished, whilst that of arterial hæmatomata, of aneurysms both arterial and arterio-venous, has increased sufficiently to make it imperative for surgeons to take notice of the change and to discuss the methods of active treatment applicable to these last conditions. Surgeons were even, to a certain extent, deluded as to their degree of frequency, this being shown by Loison’s formula :

in past wars hæmorrhage was frequent and aneurysms were rare ; in present wars it has been exactly the reverse. The aneurysms, however, remained rare. Bornhaupt, amongst 3,600 wounds seen in the ambulances at the rear, only found 8 cases ; this is a great many compared with the zero of former times, but perhaps it is not enough to warrant us having an excessive confidence in the benefit conferred by the formation of these aneurysms, and, relying on their possible appearance, to give out as a definite rule that—

“In wounds of large vessels we must no longer put on a ligature whilst the patient is on or near the field of battle, but we must rest content with compression and with securing immobility of the limb. The wounded man, transported at once to the rear, and placed in a fixed ambulance which he reaches after an interval it is impossible to specify, can, if necessary, be treated there for his aneurysm.

“This maxim was suggested to us during the Manchurian War by a surgeon who saw the wounded in the rear—that is to say, that he only saw a part of the scene ; but Manteuffel, whose experience, on the contrary, was acquired on the field of battle and at the halting-places of the troops, had been struck by the grave nature of the hæmorrhages that occurred under fire, and had seen on the line of march cases of gangrene brought on and hastened by hæmostatic compression continued for too long a time, and finally hæmorrhagic relapses due to the displacement of clots during the transport. Manteuffel remained an adherent of the practice of rapid ligature and of keeping the patient immobilized on the spot. ‘One must not have seen,’ he says, ‘these bloodless corpses abandoned in large numbers at every station by the convoys of wounded in order to realize the gravity of wounds of vessels, in spite of their apparently benignant nature.’

“Such are the sights the surgeon sees, such is the very best opinion. It is the one commonly adopted in everyday

practice. It is one I have always supported, however difficult its application during a campaign, and it is the one to which we must have recourse. I reduce it to the following formula :

In wounds of the large vessels, *ligature after compression should remain an operation of urgency* for cases in which the hæmorrhage continues; if it stops, the patient should be immobilized on the spot and closely watched. Supervision would certainly be better carried out in the first line than in halting-places on the road or on the railway. When the surgeon considers the proper time has arrived, he will send the wounded man on to the nearest hospital.

We must not, however, carry to an exaggerated degree the number of the operations or the length of the supervision, both of which must be greatly limited by the invariably grave nature of wounds of the large arteries even when caused by small modern bullets; this was proved by the remarks of Brentano during the Manchurian campaign.

On the other hand, we must not forget that lesions of arteries by projectiles of war are nearly always gaping wounds, with no retraction of the arterial coats; for these reasons they are lesions that present very unfavourable conditions for hæmostasis and spontaneous cicatrization.

Suture of the arteries has been recommended of late in bullet wounds. The large size of the vessels, their characteristics derived from loss of substance, from bruised edges, from infection, which is always to be feared, the knowledge also that suture can only be successful in absolutely aseptic wounds, all tend to militate generally against such a procedure. At most, in theory, this method, with its uncertain results in wounds by ordinary bullets, seems admissible in those linear lesions (pointed bullets, small shell splinters) which are brought to light during attempts at ligature.

Suture would certainly be more worthy of trial in wounds

of the large veins, but bleeding from these last is very much less to be feared than that from the arteries.

Carrel's direct suture with silk, either in form of a **U** or continuous, is to be preferred. Hæmostatics are only of use in arresting general oozing (solutions of alum, concentrated alcohol, antipyrine, adrenalin, hydrogen peroxide, horse serum, etc.).

Arterial hæmorrhage gives rise to acute anæmia with which we must deal. We shall speak of this later on.

Wounds of Veins.

The walls of veins are less fragile than those of arteries, and are more extensible laterally. Experiments have demonstrated that veins escape more often than arteries from the action of projectiles that graze them. When the accompanying artery is apparently contused or shows a lateral wound, the vein appears to be intact.

The traumatisms produced by bullets are *contusions, lateral wounds, complete perforations, or section*.

Contusions.—Contused veins do not exhibit the lesions that are so characteristic in arteries. Whilst the external coat presents evident signs of friction, we do not see, in the dead body, any fraying or dividing of the internal coat. Circulation of blood is not interrupted in the vessel.

Lateral Wounds.—These are indentations similar to those seen in arteries.

Total Perforation.—The same remarks apply as in the case of arteries; but already with the old bullets we find the perforations were reduced in size, often linear in shape, with insignificant contusion of the edges, and they were seen in vessels of smaller calibre.

Sections.—Caused by unequal tearing or crushing of the coats of the vessel at one point. Sometimes they are clean sections.

The wounds produced by fragments of large projectiles are very similar to the arterial lesions, but ruptures at a distance are not seen.

We lay no particular stress on the well-known sign of venous hæmorrhage: *dribbling of black blood, which can be stopped by distal compression.*

Contusion may be suspected when there is neither hæmorrhage nor sanguineous suffusion, and when the track of the bullet corresponds to that of the venous trunk.

In nearly all cases the vein remains permeable; its primary thrombosis is rare. Introduction of air into veins is a very exceptional complication, and only takes place in certain regions. Arterio-venous aneurysms, formerly very rarely seen, are less exceptional at the present time.

Compression generally suffices to arrest hæmorrhage of the large veins. *Ligature* would only be employed in cases of very severe venous bleeding with extensive external wounds, or occurring in a lesion in which we are seeking for the accompanying artery, which also has been wounded.

Complications of Wounds of the Large Vessels.

In the first rank must be placed *acute anæmia*, going as far as *apparent death*.

Acute Anæmia.—To the ordinary signs that form part of the symptomatology of hæmorrhage the following may be added: Tinnitus aurium, dizziness, shivering, nausea, vomiting, involuntary emission of urine, dilatation of the pupils, great acceleration, and at the same time smallness of the pulse, great fall in the temperature, discoloration, and flabbiness of the integuments, cold sweats, vertigo, syncope, or great tendency to it. The syncope is often providential.

These are the primary signs; later on they may be supplemented by more or less persistent general weakness, diarrhœa.

The anæmia is all the more acute when the loss of blood has been rapid; its influence on the brain and on the medulla oblongata is immediate.

Successive losses of blood delay the healing of the wounds, increase the tendency to suppuration, and open a way to infection (Kirmisson).

Hæmorrhage having been arrested, we should deal with the syncope by making the patient lie down, with the head low, by frictions, flagellation, artificial respiration, inhalations of ether, etc., elevation of the limbs. If necessary, we can make use of *subcutaneous injections of sulphuric ether* (the contents of one, two, or three Pravaz syringes), of injections of camphorated oil, of caffeine, of injections of *normal salt solution* (sea-salt 7 per 1,000). Subcutaneous injections of normal saline are employed in the least serious complications, and intravenous injections in the most serious. These injections take the place of *transfusion*, which, moreover, it would be almost impossible to make use of in war surgery, even were it more efficacious and absolutely free from danger.

Apparent Death.—Although syncope going as far as apparent death can be produced by pain, violent moral impressions, cold, extreme fatigue, or hunger, it is most often caused by severe hæmorrhage.

When syncope is prolonged—and this frequently happens—it might give rise on the field of battle to mistakes, did we not make a point at the time of interment of seeking for the positive signs of death. When there is the slightest doubt, the wounded man should be left on the spot where he has been found.

The following examples should always be borne in mind by the military surgeon :

L—, corporal in a line regiment, received a bullet in the face, and was left for dead on the Médole plain. It was only on the following day when burying the dead was being carried out that signs of life were discovered. L— is now living on his pension (Chenu).

I experienced, says Nusbaüm, an awful shock after the Battle of Orleans; October 10 and 11, 1870, when, during a gloomy, cold and dark night, I found there were a very large number of cases of lethargy. Many times we returned with four or five stretcher-bearers to wounded men who had been left for dead, although the beating of their heart could still be felt. After we had brought them in, made them warm, given them food, we succeeded in bringing them back to life. Loss of blood, exhaustion, hunger, cold, fright, seemed to me to have been the causes of the lethargy. It is dreadful to think that these poor brave young men could have remained lying in a moribund condition in the ditches at the sides of the road whilst the ambulance men went to and fro without noticing them. There is not the slightest doubt but that lethargy can change into absolute death when several hours elapse before the wounded are attended to or afforded warmth (Nusbaüm).

Traumatic Aneurysms—Arterial Aneurysms.—Traumatic aneurysms of the arteries are seen under different aspects. Sometimes we see a diffuse, tense hæmatoma with a souffle; sometimes a more or less extensive hæmatoma which a sudden hæmorrhage, when compression is taken off, has increased; at other times it is a more or less extensive infiltration *having no souffle*, the peripheric pulse being weakened, but still perceptible (Laurent). It can be easily understood that these last aneurysms are not recognized at the beginning of a campaign; this has been pointed out by Professor Laurent of Brussels. Sometimes the hæmatoma is tense, very painful, and infected. It might be taken for a vast phlegmonous exudation, which one might be tempted to incise. It is well known that such errors have been committed by the greatest surgeons.

After several weeks or months of waiting, during which time the cellular tissue of the limb which has been compressed by the blood has had time to become organized, to thicken, to form a genuine sac, we have to deal more often with a localized, well circumscribed, small, hard tumour which has a souffle; this constitutes the arterial or arterio-venous aneurysm ripe for operation.

In all cases the treatment—that is to say, the operation—should

be in the hands of a skilled surgeon, for it is difficult and requires nerve.

This operation in primary diffuse arterial hæmatoma consists, after preliminary compression at some distance of the principal artery, in *the free laying open of the sac*, search after the wounded vessel, *ligature below and above* the lateral perforation, or the through-and-through perforation, and cross-section of all that remains of the divided vessel.

When the operation, instead of being performed at once, has been delayed for a week or two, the changes that have taken place in the sac, in its contents, or in the neighbouring parts, render the search after the artery more difficult, but the method of closing it is the same.

In a completely circumscribed aneurysm recourse must be had to one of the following plans, which at the present time are both classical : (1) *Dissecting out the aneurysm like a tumour* and removing it, after having ligatured the artery both above and below ; (2) *opening the sac*, and search for the artery in its lowest part. The vessel is then tied with a double ligature, and the sac excised either partially or completely.

Extirpation, which nowadays is the operation of choice, gives favourable results in these cases. After the Manchurian War, Bornhaupt mentioned fourteen cases of traumatic aneurysm treated by this method about four weeks after the wound had been received ; a cure was obtained in all the fourteen. Saïgo, after the same campaign, reported fourteen cases of cure among fifteen extirpations of arterial aneurysms. The results obtained by Professor Laurent of Brussels are quite as conclusive.

Arterio-Venous Aneurysms.—Surgeons have been struck by the relative frequency of arterio-venous aneurysms in recent wars. Whilst during the 1870-71 war only 1 case in 2,000 wounded was noticed, Hildebrandt has seen 4 cases in 100 wounds of the vessels. In the

Morocco campaign many wounded were treated in our base hospitals for these aneurysms (Rouvillois). During the present war we should make a point of computing the number of these cases, and of elucidating some points in their history that are still obscure.

Arterio-venous aneurysms occur after complete arterio-venous perforation, after an indentation of both the artery and the vein by a projectile that had insinuated itself between them, or, finally, after a double arterio-venous contusion, or after a contusion of a vessel in close proximity to a traumatic indentation in another.

These aneurysms present themselves under two principal clinical aspects: Sometimes we see a hæmatoma which has occurred at once that is diffuse, progressive, becoming rapidly of an enormous size, threatening the whole limb with rupture and gangrene, very painful, easily recognizable by its intense souffle, whose thrill is carried for a considerable distance. Sometimes we see a progressive circumscribed tumefaction of moderate size, which seems to indicate expectant measures as much as the first points to immediate ligature or amputation. Occasionally we see a tumour that appears at a late moment without any notable hæmorrhage; in reality it is an aneurysmal varix.

These different characteristics partly depend on the kind of lesion. Two indentations tend to give rise to aneurysmal varix; arterio-venous contusion to the late tumour; extensive perforation and indentations to rapid tumefaction.

The sac of an organized aneurysm is either on the side of the vessel or completely surrounding it.

As a general rule these aneurysms should be treated at the rear by a skilled surgeon, as is done with arterial aneurysms whose condition is not threatening; but when they develop very rapidly, they necessitate *immediate ligature* or a more simple operation—namely, *amputation*. It really seems that on this point there ought to be no further discussion.

Vital interests are here concerned, and as, at the beginning, any medical man may be left in charge of the case, he must not hesitate to amputate.

Under other conditions we may employ conservative methods. *Ligature at a distance* has been condemned; it is insufficient. *Extirpation* entails injurious damage to a limb, the vitality of which is already much impaired. We must have recourse to *incision of the sac followed by ligature in the sac* of the artery and the vein above and below the lesion.

Suture can only be successful in cases of fissure or very small indentation of the artery or of the vein. If necessary it may be combined with ligature of the second vessel.

Late and Secondary Hæmorrhage.—*Late hæmorrhage* generally comes on at the end of twenty-four or forty-eight hours after either spontaneous or surgically produced hæmorrhage.

Cessation of syncope, untimely movements on the part of the wounded man, or those caused during the application of the dressings, or during the carrying out of exploration whilst searching for splinters of bone, movements caused by transport, all tend to displace the obturating clots.

Late hæmorrhage is much more rarely seen after wounds of veins than after wounds of arteries.

Secondary Hæmorrhage.—It is specially connected with a septic condition of the wound. It was very frequent in former times, but has become rare in modern days; but it still is seen (septicæmia, scurvy, etc.).

The fall of the scab that had formed on a contused artery, ulceration of a vessel by a splinter, by a metallic foreign body, more often disaggregation of a clot through suppuration, premature falling of a septic or even of an aseptic ligature, may all be causes of secondary hæmorrhage.

We speak of hæmorrhage occurring from the eighth to

the fifteenth day as precocious, and of hæmorrhage appearing from the thirtieth to the fortieth day as late.

Very often, and especially when it is connected with the falling of scabs, the hæmorrhage is indicated by premonitory symptoms which the surgeon must not fail to notice: rigors, vague pains, slight oozing of blood, renewed and increasing in quantity in proportion as the scab becomes more separated, and staining the dressings a *roseate hue* (Roux).

Direct or indirect compression are the first methods to employ until it is possible without further delay to *ligature the two divided ends of the vessel*. Such is the treatment for choice. Putting a ligature on at a distance would be a deplorable mistake.

Hot water, solutions of alum, of adrenalin, of gelatine (5 to 10 grammes of gelatine absolutely sterilized in a litre of normal saline), of antipyrin, of antidiphtheritic serum, are all useful; they should be employed alone or with direct compression and in conjunction with ergotine in hypodermic injections (fluid extract of the codex—the French Pharmacopœia—0.50 in one dose, and 2.50 grammes in the twenty-four hours), white gelatine in hypodermic injections ($\frac{1}{50}$ th), chloride of calcium (4 grammes every day for four or five days), horse serum as a topic or in hypodermic injections, quinine in large doses.

CHAPTER V

WOUNDS OF THE NERVES

By reason of their form, their mobility, their elasticity, they escape to a certain extent the action of bullets, especially when these last are pointed and have only a small degree of velocity. The lesions are *contusion*, *partial abrasion*, *perforation*, *total abrasion*.

1. **Contusions.**—We find *two* degrees of contusion: In the first the contusion is trifling. The nerve does not appear to have suffered externally; in its interior a few fibres have been destroyed. In the second degree the external form of the nerve has changed, it is contracted at the place where the bullet struck, above and below it shows a spindle-shaped dilatation caused by the forcing back of the myelin. The neurilemma is separated.

2. **Partial Abrasions.**—These are more or less regular indentations with forcing back of the myelin.

3. **Perforations.**—The bullet has pierced the centre of the nerve in a linear manner, leaving the lateral portions apparently intact (Freyer). The lesions are not seen exclusively in the largest nerves. Nerves of a smaller calibre—the median, the musculo-spiral, the ulnar, with a diameter less than that of the projectile—are also perforated.

We do not know the degree of frequency of this curious variety of traumatism; it was not produced by the old bullets, and its frequency still has to be determined.

4. **Abrasions: Total Division.**—In these cases the nerve shows a solution of continuity. Its extremities are reduced to pulp and the myelin is forced back (bullets, shell splinters).

Signs of Wounds of Nerves.—Disturbance of *feeling*, of *movement* (paralysis, cramps, contractions); *disturbances* taking place at a *distance* through reflex action, these may show themselves immediately or a little while after the traumatism; they are all too well known for them to delay us.

It will be sufficient for us to point out that immediate pain, either localized or at a distance, is rare (less than half the cases), and that immediate trouble at a distance must be referred to the hysterical group of disorders.

Consecutive disturbances are those of *feeling*, of *motility*, of *nutrition*, or they may depend on a processus of *irritation*.

If the aseptic evolution of wounds of nerves by firearms takes place without important phenomena of irritation, in cases of infection, of *acute neuritis*, both the localized and the radiating pain is acute, tenacious, intermittent, or continuous, and sometimes accompanied by fever, spasm, and contraction. The neuritis, when it becomes *chronic*, may assume the *ascending form*, and extend even to the medullary roots; this, however, is less frequent than it used to be. In some cases the pains bring on a regular *sensorial tetanus* (Weir Mitchell). Hyperæsthesia is extreme, and is awakened by the slightest contact, and in a far greater degree at the slightest fear of contact. *Causalgia*, glossiness of the skin, and acute disturbances of nutrition due to neuritis, are well known; but let us remind medical men that in extreme cases, even well-marked cerebral disturbance has been remarked.

Although far more rare nowadays, thanks to the aseptic evolution of many of the wounds, neurotic phenomena are none the less complications that are to be feared; there-

fore we should strive to prevent them or to limit them by devoting particular and special care to wounds occurring in the regions of the large nerves.

General diagnosis of wounds of the nerves by projectiles is in most cases easy ; but, when it is a question of determining the nature of the lesion, the solution of the problem becomes difficult, often impossible. A great deal of quite unjustifiable interference is thus explained.

Treatment.—The treatment, which not long ago was reduced to the symptomatic indications, has been enriched at the end of recent wars by improvements adapted from the technique of everyday surgery. In order to appreciate their full value we will revert to what we recently said on the subject before the Academy of Medicine (February 24, 1914).*

This technique, we wish first to point out, concerns specially the work of the *surgeons at the rear*. *At the front any intervention seems to be contra-indicated*, were it only on account of the extreme difficulties of the diagnosis, of the complexity of a deceptive and excessive symptomatology, which takes time to be elucidated ; therefore at the front we must content ourselves with dressing the wound and avoiding all irritation.

It is all the more indicated to make use of this technique at the rear, inasmuch as surgery of the nerves is not so urgent with regard to the time of intervention as surgery of the arteries ; and inasmuch as in the hospitals at the rear the surgeon can undertake these operations without being hurried, at the hour he chooses, and under the best surrounding conditions. One of the conditions for successful operation in these cases is very strict asepsis.

We should certainly hesitate to put sutures into wounds

* Report on a work by Professor Laurent of Brussels, *Aneurysms and Wounds of Nerves in War Surgery*, O. C.

threatened with infection. *It is far preferable to wait for their cicatrization before intervening.*

On the other hand, the large nerves are nearly always wounded at the same time as the arteries, of which they are the satellites ; and the surgeon naturally has his attention drawn to their injuries only at a consecutive period when he operates on the accompanying aneurysm, the treatment of which would plainly occupy a more important place than that of the nerve lesion.

“The lesions presented by nerves injured by projectiles are, we remarked, at the same time less favourable for successful operation and more favourable for spontaneous cicatrization than are wounds we see in everyday practice. In these last the nervous trunks have nearly always been divided by an instrument or by something sharp ; they have not experienced loss of substance, but, if healing has taken place with formation of a neuroma, its excision is not an addition to the loss of substance resulting from the primary traumatism. This consideration, which up to now has not been insisted upon, should not be lost sight of by those who wish to form an appreciation of the indications, the degree of usefulness, and the results of operative interference.

“Let us discuss their expediency, first in cases of *slight contusions*. Although these show originally sensori-motor disturbances which might put us on the wrong scent with regard to their real prognosis, the continuity of the nerve is not interrupted in this instance.

“In *extensive contusions* the nerve is deeply injured ; the forced-back myeline often gives rise to the immediate formation of a small neuroma above the point of injury. Here, again, however, the continuity of the nerve is not interrupted. Why, then, should we operate ? Again, if we intervene a little time after the traumatism, to what extent could we carry the loss of substance necessi-

tated by the refreshing of the ends of the nerve before suturing?

“Amongst *abrasions*, some are slight, and only involve to very small extent the circumference of the nervous trunk. Could we but recognize them clinically, no one would dream of meddling with them. There are some, however, that are *complete* or *nearly complete*, and the forcing back of the myeline is added to the loss of substance. At the period when one might think of an operation, one must look forward to having to treat a pretty extensive loss of substance joined to a nervous deterioration, which itself is rather large, and has undefined limits. Sutures might be difficult to obtain, and their success problematical. These lesions, which are but little circumscribed, are especially dangerous when the nerve has been injured by a projectile having a very great velocity—that is to say, one that has been fired from a short distance.

“In *perforations*, any immediate intervention would be inexplicable. Freyer, face to face with three wounded men showing such lesions, abstained from all surgical interference. Really, one does not see what other course he could have followed.

“It may be gathered from these statements that *it seems very difficult to recommend nowadays any active treatment for wounds of nerves by projectiles within a short period from the occurrence of the traumatism*, excepting in those cases where the nerve is pierced by a splinter, this having been discovered in the course of surgical intervention for some other cause.

“Putting aside such cases as these last, we consider it *better to allow Nature either to undertake repair, or to show evidence of its incapacity to do so*.

“On the other hand, in presence of this incapacity, everything must be tried to help Nature. Surgical therapeutics, the results of which have not as yet been entirely satis-

factory, offer many methods for us to utilize, such as *displacement, suturing at a distance* according to Assaky's plan, *implantations*, and *splitting and grafting*.

"A nerve compressed by a fibrous band or by a callus in the process of formation should be liberated and transposed; *partial excisions of neuromata* should be done, *followed by direct suturing*; *total excisions of neuromata*, also followed by direct suturing; a splinter that has pierced a nerve should be removed; when there is loss of substance, we should have recourse to end-to-end anastomosis."

In order to make a protecting canal for these important elements of repair, we can, following the example of Professor Laurent of Brussels, form a sheath for the nerve in a strip of fascia. This surgeon has chiefly taken his strips from the extensive aponeurosis of the fascia lata. From it he detaches, in the form of a graft, a square piece of from 3 to 4 centimetres, that he sutures by means of silk or catgut all round the united ends of the nerve.

This way of forming a sheath is only an imitation of the method of Van Lair—the so-called *tubulization*. This surgeon made each divided extremity of the nerve penetrate a tube of decalcified bone.

Foratimi (1904) proposed making use of arterial or venous fragments taken from a freshly killed calf; and these pieces were treated by immersion in formol and kept in alcohol.*

Two Japanese surgeons, Drs. Hashimoto and Takuoka, during the Manchurian War, made use of the method of Foratimi, and had nothing but praise for it.†

* Foratimi, *Arch. f. Kl. Chir.*, 1904.

† The following is the method of preparation to which these surgeons had recourse: Arteries and veins of different sizes are excised with anti-septic precautions from a recently killed calf; they are placed on a glass stick; after hardening in 5 or 10 per cent. formol for forty-eight hours, they are washed in running water for thirty hours, they are then boiled for twenty minutes, and kept in alcohol at 95°. Reabsorption will take place in from two to four months. The same surgeons have

In the case of one of his men who had a bayonet wound, and on whom he had incised a neuroma of the median nerve, Dr. Laurent formed a sheath for the nerve from a fresh, quite unprepared piece of the jugular vein of a sheep. A sheath made of a graft was not successful.

The simple proposal made by M. Cunéo seems to have been forgotten: it consisted in making use, for an isolating tubular piece, of a portion of a large superficial vein taken from the patient himself. Perhaps this is the method of the future.* We may call it an auto-graft. The method presents all the most favourable conditions for its revival, it is always ready to hand, and its asepsis is perfect.

On the whole, the questions dealing with the primary and consecutive treatment of wounds of the nerves have not yet had sufficient light thrown on them. The various forms of treatment are numerous, but their results have not been fully studied. These points are worthy of being taken up and completed during the present campaign.

In dealing with neuritis the surgeon will fall back on sedatives, on neurotomy, and on neurotripsy. We cannot in such cases speak too highly of powerful, extreme, and instantaneous compression made by the thumb on a level with the wound when the nerves are superficial. To this species of neurotripsy we owe some remarkable successes in old cases that had not been ameliorated by division or amputation of the nerves, and this in wounded soldiers who could not possibly be suspected of hysteria.†

also another way of operating, which consists in displacing to a new position in the thickness of the adjoining muscles nerves that have been sutured. They have obtained excellent results.

* Cunéo, *Treatise by Le Dentu and Delbet*, article "Nerves."

† Delorme, "On the Disappearance of Neuritic Symptoms by Localized and Forcible Compression," Desportes Prize. *Journal de Médecine et de Chirurgie Pratiques*, June 25, 1896.

CHAPTER VI

FOREIGN BODIES

FOREIGN bodies which frequently cause complications in gunshot wounds are of different nature : (1) The projectile in its entirety ; (2) objects torn off by the projectile from wearing apparel, from articles of equipment, accoutrement, or armament (buttons, fragments of clothing, nails, and fragments of leather from boots) ; (3) articles carried in the pockets (spectacles, coins, etc.) ; (4) fragments separated by the projectile in its flight or on exploding (earth, stone, or wood) ; (5) fragments from the equipment, or even from the *dead bodies near by*.

Of all these various foreign bodies, the projectile itself and pieces of clothing are those which are most frequently found in the wound. We find them generally in cul-de-sac wounds, but setons may also be complicated by them.

The projectile is either whole or in fragments, in its regular form, or having lost its shape (contact with some part of the bones or with the ground). Its changes of shape and divisions must be well understood. They differ according to whether the bullet is of soft lead, has a protective covering, or is in a single piece of metal.

Bullets of Soft Lead.—Bullets of soft lead, which are still represented by shrapnel or case-shot, spread out irregularly on touching the ground ; they enter the tissues, but not very deeply, making a large opening, often more broad than long. In contact with the bones they undergo typical

changes of shape, which may be spoken of as—(1) *Lateral changes* ; (2) *antero-posterior changes* ; (3) *division into fragments*.

The first consist of very regular, continuous abrasions, which *only occupy a very small portion of the diameter of the bullet*.

The second show the *point turned back*, the bullet more or less flattened out, the flattening being sometimes regularly distributed from the centre, sometimes deviated to one side.

In the third case *the bullet is completely compressed*, flattened, and spread out like *a large daisy*, the rear-piece forming the centre of the flower. It is in this extreme division into fragments that the projectile is broken up into very small pieces.

Bullet with a Protective Covering.—In experimental firing at dead bodies, we have studied with Professor Chavasse, and we have carefully described the changes in shape of bullets with a protective envelope, of the Lebel M bullet, to which the German Mauser bullet and also the present Austrian Mannlicher are analogous.*

Although the protected bullet, when compared with the projectiles of soft lead, is less frequently changed in shape and less frequently arrested in the tissues, we have noticed—and the facts may still be of importance—

(a) *That this division into fragments was seen all the more readily, and that it was all the more complete the higher the velocity of the bullet and the greater the resistance of the bone struck.*

(b) *That bullets, even when fired from middle distances, were arrested in the tissues—a point at that time much contested.*

(c) *That protected bullets caused divisions into fragments of a special nature, this being due to their structure.*

The changes of shape of these protected projectiles are—(1) *At their point* ; (2) *laterally* ; (3) *partial separation of the protecting envelope, with antero-posterior change of shape of the*

* E. Delorme, *Treatise on War Surgery*, vol. ii., p. 96 and following.

projectile ; (4) segmentation, the leaden nucleus being completely severed from its envelope.

In most cases these changes of shape are isolated ; they can be combined in one and the same bullet.

1. *Changes of Shape of the Point* consist of a cup-like depression of the flattened apex, or of its surrounding parts. At a more advanced degree all the conical part of the projectile has undergone a lateral spreading out in a more or less concave form, with rounded edges ; generally there are fissures in the envelope.

CHANGES IN SHAPE OF BULLETS THAT HAVE STRUCK BONES.

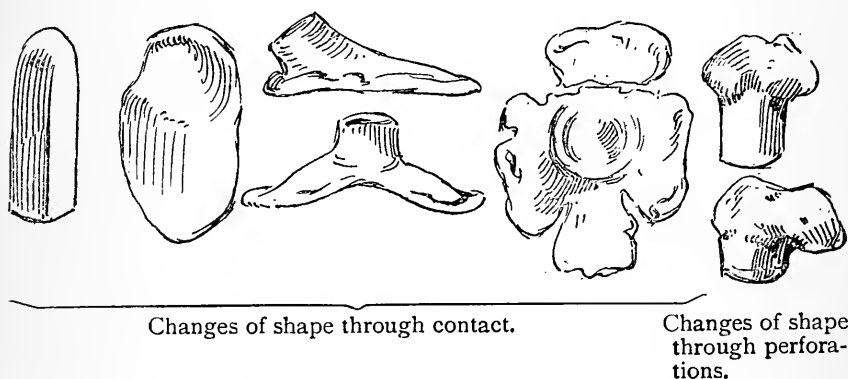


FIG. 5.—BULLETS OF SOFT LEAD.

2. *Lateral Depressions* are slight as a rule, and may be observed on any point of the cylindrical surface of the bullet.

3. The bullet coming straight into contact with a resistant body with very considerable vital force is subjected to a pressure which spreads out its anterior part ; *the envelope bursts on a level with the flattened-out extremity.*

Sometimes the change of shape consists of a lateral bending over, either spiral or direct, with or without rupture of envelope.

4. *Splitting into Fragments with Separation of the Bullet's*

Nucleus from the Envelope.—Dehiscence of the envelope facilitates its separation from the nucleus. This separation is either complete or incomplete. When it is complete, each fragment follows a more or less extended but different track.

In some cases splitting into fragments and separation are regular; in others, the envelope is subdivided into small scales, distorted with cutting edges. The nucleus crumbles into dust or into small fragments. The whole mass has been projected in a shower and has exploded. Even in

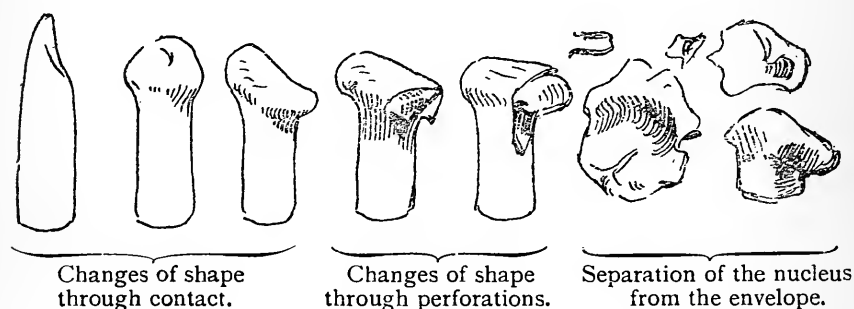


FIG. 6.—BULLETS WITH ENVELOPE.

these extreme cases the nucleus is represented by a fragment larger than the others. It would be folly to search for such fragments, the whole limb would have to be cut into, and even then they would not be found. These divergent seed-like fragments are well shown by radiography.

These changes of shape and large segments occur through contact with the diaphyses, but they are also seen when the bullet has touched hard ground before reaching the body. The bullet now becomes a foreign body, consisting of one or many irregular fragments of the envelope or of the nucleus.

During the Cuban War awful traumatisms were caused by very much broken up and ricochettted bullets. During

a riot in St. Petersburg, when the order was given, with a humanitarian purpose in view, to aim at the ground when firing, wounds of an exceptionally serious character were caused by the bullets which had ricocheted from the paved road. We saw the same thing happen at Fourmies.

This dividing into fragments is brought about by the active force of the bullet that has an envelope. With a very high velocity, the struggle between power and resistance is at the same time so instantaneous and so intense, that in most cases the bullet is subdivided into very small fragments. On the contrary, with less velocity it passes through the diaphyses without notable change of shape, or even without any change of shape whatever.

Bullet D.—The changes of shape the *D* bullet, which, as we know, is formed of a single piece of brass, undergoes when in contact with the soil in ricochetting, in striking against metallic parts of the soldier's equipment, or against hard parts of the human body (bones), are far less frequent and not nearly so pronounced as those of other bullets. Bullets changed in shape through contact with stony ground retain but little penetrating power, and after having pierced the tissues by a large aperture, they remain at a short distance from the skin.

Average changes of shape consist generally of a turning up of the point, which becomes more or less curved, sometimes bent at right angles. The changes of shape of the base show flattening or incurvation, those of the body inflection.

Slight changes of shape are of the same nature, but not so pronounced. Prominent and considerable changes of shape are rarely observed when bones are struck by the bullet. After striking against very resistant obstacles, such as certain kinds of stone, gun-shields, or iron plating, bullets may be flattened out into the form of a daisy and become subdivided; this, however, is rare. Finally, the *D* bullet

has its shape altered rather on striking against external obstacles than against the bones; when it encounters the latter the alteration in shape is but slight.

Bullets from Shrapnel.—These bullets of hardened lead, formed of two parts joined together, are frequently broken into two symmetrical halves. They undergo similar changes of shape to those seen in soft-lead bullets (lateral, antero-posterior alterations of shape, deformation, segmentation). It must not be forgotten that the flat facets they show are due to their collisions against neighbouring bullets at the moment of the shell's explosion.

Fragments of Clothing are typified either by conglomerate large pieces of material or of many very small bits. The conglomeration is made up of superposed, united pieces in layers of the soldier's tunic, flannel band, shirt, trousers and drawers, the number of pieces being much increased when the clothing happens to be in folds. The diametrical dimensions of the conglomeration are a little less than the bullet's surface of impaction. The projectile produces abrasion, especially when its active power is sufficiently great to enable it to act mechanically as a punch.

This conglomeration of pieces of clothing, which is frequently observed with soft-lead bullets, and with bullets having a defensive envelope and a flattened apex, is not found in wounds made by conical bullets fired point-blank. On the contrary, they are met with in wounds due to deflected bullets, and usually in wounds from shrapnel and from shell splinters.

In our experiments on dead bodies with the Gras and Lebel bullets, we were somewhat surprised to find that in most cases the greater part of the track of the bullet was *lined with thin filaments* of wool emanating from the trousers and the overcoat, easily recognized by their colour.* The presence in the wound of these very infinitesimal pieces

* E. Delorme, *Treatise on War Surgery*, vol. i., p. 553.

has been confirmed by all those who have carried out similar experiments. Reverdin says that, as a result of his experiments, a wound made through a cloth uniform by bullets having a protecting envelope is, nearly without exception, complicated by the presence of very small débris, especially just under the skin at the aperture of entry.

As we have often pointed out, the bullet, when it comes in contact with unyielding fasciæ, the fibres of which in most cases it simply thrusts aside, gets rid of the fragments it has carried along. The latter are not only found near the aperture of entry in the subjacent enveloping fasciæ, but also in other parts of the track, even in Pirogoff's pouch—that is to say, between the separated skin and the last layer of aponeurosis traversed by the bullet before reaching the aperture of exit (Reverdin).

An interesting fact is the projection of *these filaments into the thickness of the tissues all around the track at distances we are far from suspecting, sometimes attaining several centimetres.*

The question dealing with the lodgment of fragments of clothing in wounds is too intimately connected with the evolution of the traumatism for us to neglect its present study; at this point we can say that it is specially important to recognize the presence of these conglomerations of detached clothing. Now, if diagnosis of metallic foreign bodies is easy, thanks to the methods of exploration now in use, that of particles of clothing seems impossible, as there is nothing to indicate their presence in the midst of the tissues. Such, indeed, would be the case were there not an unfailing means of ascertaining their presence, and that is by direct examination of the clothes themselves. With reference to this question we will formulate the following data:

1. *Examination of the clothes, often impossible, besides being useless, at the front, is absolutely necessary when the wounded man has been removed to the rear.*

2. *At the front we should be careful not to sacrifice clothing through which a bullet has penetrated by cutting it where it has been perforated. At the rear one should be careful not to deprive the wounded man of his garments, nor to WASH THEM, as this would alter their aspect. A soiled and torn uniform must not be looked upon as rags, but rather as a trophy; moreover, it is a valuable component part of a most useful diagnosis, which may have to be renewed by the different surgeons who, in succession, may have the wounded under their charge.*

3. When, after the edges of the apertures have been carefully drawn together, we find, in spite of the primary and delusive gaping, *that there is no notable loss of substance*, we may affirm that the wound is *free from a conglomeration of pieces of clothing*.*

4. *Not only one, but every piece of the wounded man's clothing should be examined, as well as the linings, for linen, being less elastic than cloth, its fragments are frequently more noticeable than those of the latter; they may even be present as isolated foreign bodies.*

Diagnosis. — *A single wound, hard and painful swelling, localized pain* at some distance from the aperture of entry, even in the case of setons, are indicative of the presence of metallic foreign bodies.

The numerous methods of exploration and diagnosis that authors formerly dwelt on with such complacency, from the metallic probe to the electric exploring apparatus, have now only an historical value.

All these methods are now superseded by *radiography*, and not only does radiography allow us to attest the

* Although in theory it is not important to examine the aperture of exit through which the pieces of clothing might have emerged, as they have already been expelled by the bullet, nevertheless we advise an examination of both apertures, because it is not always possible to diagnose one from the other.

presence of foreign bodies, yet it is perhaps going too far to say that it shows us precisely the place where they are located.

Wounds in which foreign bodies are thought to be lodged should be examined in the rear by *radiography*, not by *radioscopy*. If the ambulance is not provided with apparatus, the wounded men should be taken to the nearest hospital to undergo an examination, after which they must be sent back to the point from which they started. Each patient is entitled to one examination. It gives the origin of the mischief.

Treatment.—The question as to the expediency of extracting *metallic foreign bodies* is one that has been greatly discussed. Those lodged in the soft tissues are generally very well tolerated. It is well known nowadays that in this tolerance their own characteristics, their nature, their form, their size, are not of nearly so much importance as asepsis of the wound.

In a septic or suppurating wound a metallic foreign body is not tolerated. Therefore at present, by common consent, it is admitted that—

1. *A metallic foreign body, which is tolerated, causing neither uneasiness nor pain, should be left alone.*

2. *A foreign body that gives rise to pain, is badly tolerated, that causes uneasiness by coming into contact with vessels or nerves, or that is situated in a focus of suppuration, must be removed.*

3. *A bullet that is almost level with the skin may be removed to gratify the patient, provided that the incision does not open a cavity, and provided also the ablation be done in a permanent shelter where all the usual precautions can be taken.*

Another reason which militates in favour of this last condition is that certain foreign bodies, which seem to be superficial and easy of extraction in the light of radiography, give rise in many cases to difficulties that protract the operation.

4. *A shell fragment that is large, irregular, and sharp, and also a shrapnel bullet, must ALWAYS be removed shortly after the traumatism; this should be done in a permanent shelter either at the front or in the rear.*

5. Ablation of these last foreign metallic bodies is specially necessary, because they *close the cul-de-sac* in which are lodged infecting foreign bodies derived from the clothes, and because ablation of the metallic body is the best way of setting free fragments of wearing apparel.

6. Removal of these last metallic bodies should be carried out VERY SHORTLY after the traumatism, either *immediately or a few days after.*

Special instruments are not necessary for the extraction of metallic foreign bodies. At the bottom of the exploratory incision, which must be *methodically* carried out, great care being taken not to injure important organs, a pair of dressing or forcipressure forceps, guided by the surgeon's left forefinger, will suffice for their gentle extraction.

CHAPTER VII

BONY LESIONS OF THE DIAPHYSES

THERE is no traumatism that brings into such strong relief the striking differences separating war surgery from ordinary surgery as the bony lesions of the diaphyses. A surgeon who considers he can base their treatment on his general ideas would be liable, unfortunately for the wounded, to remain very inferior to the ideal of the duty he has undertaken.

The adoption of the new projectiles has brought with it no important modification in the data derived from experiments on the dead body, on the one hand, and from experience acquired in recent wars on the other.

According to world-wide statistics, lesions of the bones are seen during a campaign in a proportion of *one-fifth* of all wounds.

Cold-steel weapons lead to *sections* of the diaphyses; *projectiles* to *contusions*, *cracks*, and *fissures*, to *fractures by contact*, *perforation of one side of the bone*, *perforation right through*, and to *grooves*.

This classification should be adopted by all surgeons, in the first place because it is based on strictly exact and constant provisions, in the second place because it originates from our chief practical data.

Lesions caused by Projectiles.

Contusions.—These are either the result of direct shock or of tangential contact of the projectiles. They are very

frequently produced by bullets, but are often unperceived on account of their giving rise to no immediate signs.

At the seat of the contusion the periosteum is involved and destroyed, and the marrow may or may not show either circumscribed or extensive pouring out of blood.

Cracks and Fissures.—Isolated cracks and fissures of the diaphyses are also frequent, but, like bony contusions, they nearly always are unperceived. Wounded men who

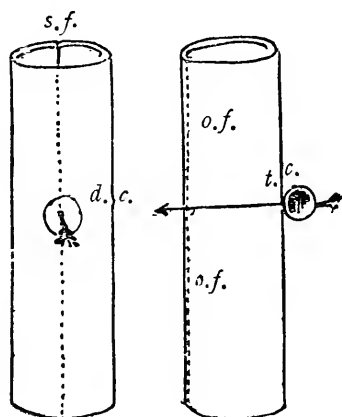


FIG. 7.

s.f., Symmetrical fissure (direct contact); *o.f.*, opposite fissure (tangential contact); *d.c.*, direct contact; *t.c.*, tangential contact.

present long fissures of the bones of the lower limbs can walk when left to themselves.

A *crack* is a *cleft* whose sides are very near together, and can hardly be seen; a fissure is a *visible cleft* whose sides are widely separated.

The most remarkable are the *longitudinal* cracks and fissures, often very extensive; they are either single or multiple, but some are oblique, some curved. *Isolated cracks and fissures are outlines of those that fix the limits of fractures by contact*, of which they show the direction and position (Delorme).

Symmetrical fissure and *opposite fissure* are the most striking

and the most constant lesions of the diaphyses. The former furrows the side of the bone that has not been hit, and *this happens in the plane passing through the point of contact of the projectile*. It is the result of *direct* contact of the bullet (s.f.) *Opposite fissure* is also seen on the side of the bone that has not been hit, but this fissure is found on a *perpendicular plane to the track of the projectile*. It is the result of a *tangential* contact (o.f.).

These fissures are seen on all the long bones. Absolute diagnosis up to now has been very difficult, for *neither* in

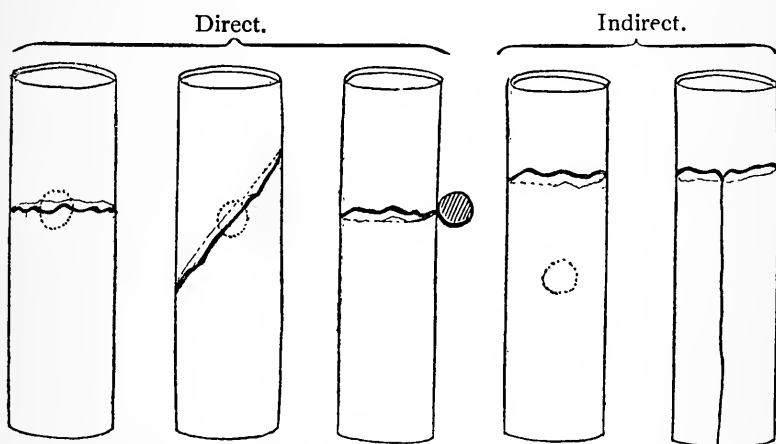


FIG. 8.—CONTACT FRACTURES (TRANSVERSE AND OBLIQUE).

bone contusions *or* in fissures was there anything characteristic with regard to *shock, inability to use the limb, denudation of the bone, deviation in the course of the projectile, its change of shape if it remained in the limb, increase in size of the aperture of exit, relationship of the track to the bone*.

Radiography sometimes affords a certain diagnosis, but this is not constant.

Fractures by Contact.—These are the result of the *direct* or *indirect* (tangential) contact of a bullet fired point-blank, or that has ricocheted or been deflected.

We recognize fractures by contact as *transverse, oblique*—

that is to say, forming a simple line of fracture; and *fractures that have large splinters of bone*.

TRANSVERSE AND OBLIQUE FRACTURES.—Relying on our experience, we have asserted that *transverse and oblique fractures* are not very rare. The teachings of the Transvaal War have confirmed our dictum, and the present war strengthens it still more.

Sometimes the fracture corresponds exactly to the point

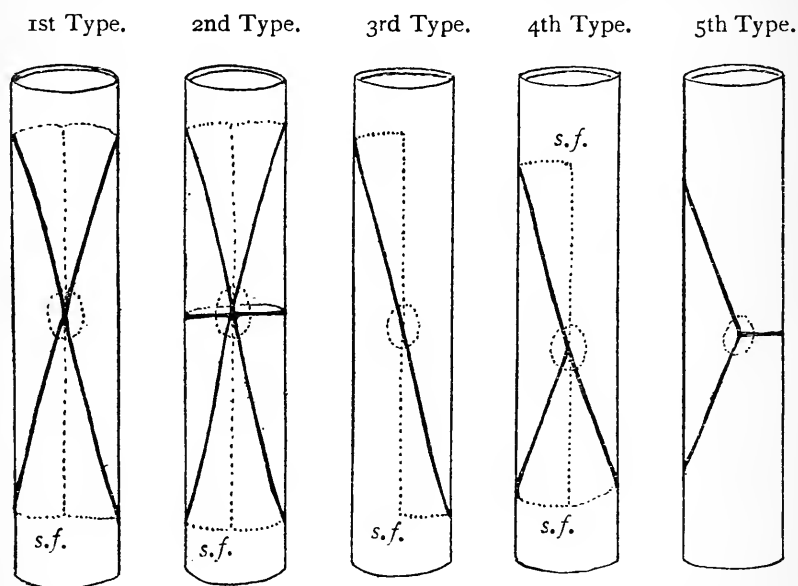


FIG. 9.—CONTACT FRACTURES WITH LARGE SPLINTERS (NO COMMINUTION).

of the bone hit by the bullet (*direct fracture*), sometimes it occurs at 2, 3, 10 centimetres from the place of the bullet's contact (*indirect fracture*). Indirect fracture can be single or double, and its line can either be simple or accompanied by longitudinal fissures.

FRACTURES WITH LARGE SPLINTERS.—In these fractures, which are well known ever since we fully described them, the lesions extend more in the direction of the axis of the bone than perpendicularly to it.

Five different types will be found in the illustration on p. 74.

First Type: This is the most important. From the point of impact extend four diverging curvilinear fissures, the convexity of which is turned towards the axis of the diaphysis; these fissures are united on the side of bone which is not hit to the large symmetrical longitudinal fissure (*s.f.*). These fissures enclose two large triangular splinters facing one another at their apex; they are placed between the superior and inferior fragments; their *pointed extremities have undergone no loss of substance*. This is a point to remember.

These splinters may occupy a quarter, a third, or one-half of the bone.

At the point of contact the periosteum is destroyed, the bone contused; all along the fissures it is raised by blood and marrow reduced to pulp; suffusion of blood is seen in the medulla.

Second Type: This is a *fracture with large splinters subdivided transversely or obliquely at their centre*. (Rare.)

Third Type: *Oblique longitudinal spiroid fracture*. On the side of the bone corresponding to the point of contact there is a very oblique line in the form of an elongated **S**, which by its curved extremities joins the longitudinal *symmetrical* fissure. This exceptional type is almost exclusively seen in the femur (upper third).

Fourth Type: *Fracture having the shape of a V, cuneiform, and with one large splinter*. It is the fracture of the first type, or in the form of an **X**, in which the line of one of the splinters is wanting. Of the two fragments one has the shape of a **V**, or of a wedge, and is sometimes above, sometimes below; the other takes the form of a radish. This fracture is frequent.

Fifth Type: *Fracture with one splinter, and transverse subdivision of the remainder of the bone*. (Rare.)

Such are the simple types, *without comminution*, that are produced on the diaphyses by contact with bullets. The bone is fissured or broken; the fragments, whose limits are marked, are either held closely together by their serrated edges (in which case the continuity of the limb will not be interfered with so long as the bone is not subjected to any shock or to untimely exploration), or else the fragments and the splinters are from the very beginning separated as in an ordinary fracture.

At all events, the bone has not suffered, either in its splinters or in its fragments, any loss of substance, and the periosteum is still

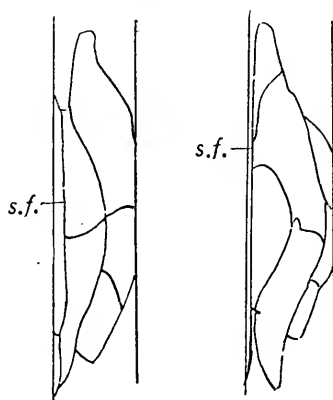


FIG. 10.—CONTACT FRACTURES, WITH LARGE SPLINTERS AND COMMUNITION.

adherent. All these conditions are favourable to a simple and rapid cure.

If the projectile, producing the fracture by contact, has very great active force, it will give rise to *fractures by contact with comminution*. On the whole, these fractures are limited by large fissures whose direction is characteristic; but the large splinters, instead of being intact, are subdivided in one place, more rarely in two or three, by large fissural tracts, parallel to those that mark the limits of these principal splinters, sometimes by more or less vertical tracts, or by others that are perpendicular or oblique.

The periosteum, which has become separated from the bone, is raised to the level of each secondary fissural tract; but whether the subdivided splinters remain *in situ* or are displaced by the faulty position of the superior or inferior fragments, the comminuted fracture by contact retains its main characteristics: *the extremity of its fragments is SHARP, WITHOUT LOSS OF SUBSTANCE; THERE IS NO FREE SPLINTER; all the splinters are adherent.*

The conditions governing the manner of arrangement of fractures by contact with large splinters give the keynote to lesions connected with perforations or grooves, for, as we have proved, *a perforation or a groove is but a fracture by contact with a perforation or a groove superadded.*

Perforations.—By experiments we have proved that fracture caused by perforation, whether with or without comminution, is the habitual form of fracture produced by firearms.

We have recognized two kinds which have been generally accepted: *Incomplete perforations*—that is to say, *perforation of only one side of the bone*, and *complete perforations*, when *both sides of the diaphysis are involved.*

Incomplete Perforations. — Incomplete perforation — that is to say, of only one side of the bone—can only be produced (and this is easily understood) by bullets *whose velocity cannot be very great*, since they have not been able to continue their course. Therefore, as comminution of a fracture is in inverse ratio to the extent of motion acquired by the bullet, it is evident that *these fractures must always be simple in type.* On the other hand, however, we must not forget that the bullet has not only made a perforation in the diaphysis, but that, by its simple contact, before causing the perforation, it has given rise to the longitudinal fissures seen in fractures by contact.

It is the first **X** type of *fractures by contact* that is connected with *perforation of only one side of the bone.* With the fissures

and the large splinters, which we need not describe again, there is an orifice in the bone, generally rounded in shape, sometimes oval, whose diametrical dimensions are *less* than those of the bullet. The latter may be in the medullary canal at the level of its aperture of entry; occasionally it has slipped down the canal, or it may have come into contact with the inside of the opposite wall of the bone,

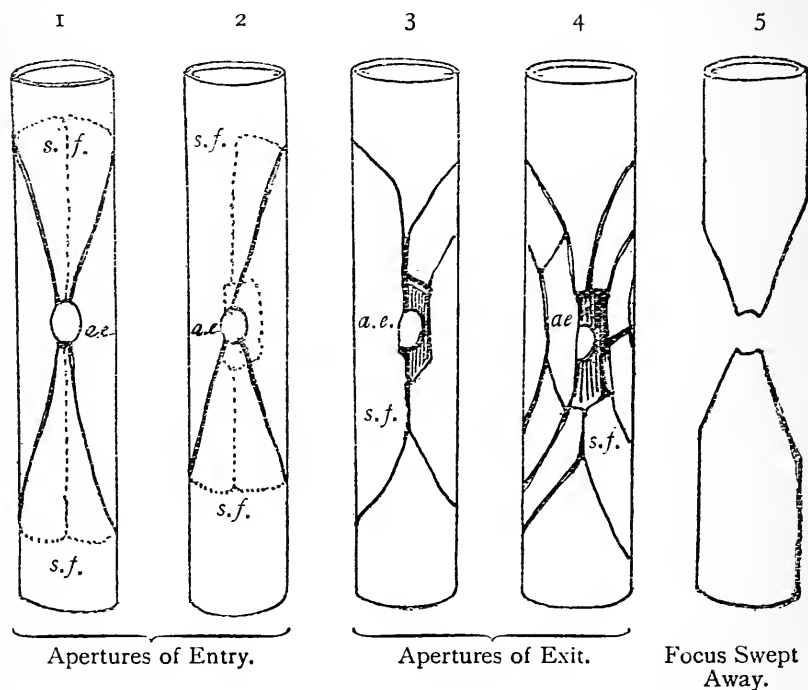


FIG. 11.—FRACTURES WITH COMPLETE PERFORATION.

giving rise to some short splinters, but as it has not sufficient strength left to emerge, it remains where it is.

COMPLETE PERFORATIONS.—The projectile that produces them having a sufficient but variable active power to go through the two bony walls, complete perforations are either more or less *simple*, or else *comminuted*, even *excessively comminuted*.

In regard to the general direction of the fissures, the

limitation of the splinters, and the shape of the fragments, fracture by complete perforation nearly always shows much resemblance to fracture by contact with two more or less subdivided large lateral splinters, or to cuneiform V-shaped fractures (Fig. 11, 1 and 2).

The bony aperture of *entry* is circular and regular, of the same dimensions as the projectile, or smaller, occasionally oval in shape.

The bony *aperture of exit* is variable in form. Rarely

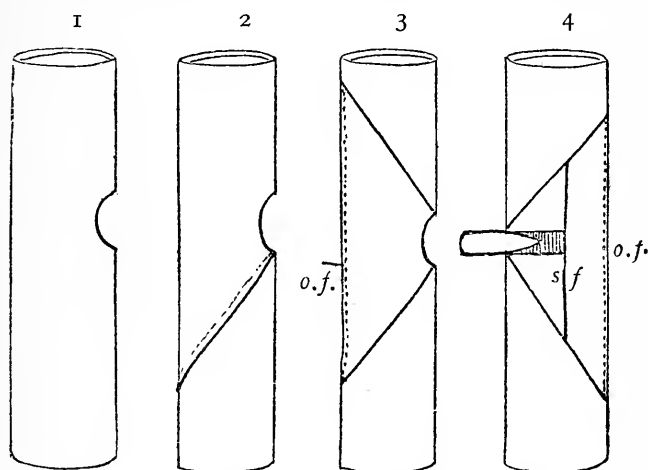


FIG. 12.—FRACTURES BY GROOVES.

1. Groove of ridge. 2. Groove of ridge with oblique fracture. 3. Groove with one or two large lateral splinters. 4. Shows the breach made by the bullet in a subdivision of the large splinter.

circular and regular, it is nearly always, owing to loss of substance, more or less quadrilateral, its borders being formed by the splinters that the projectile has detached (Fig. 11, 3 and 4). These splinters, more or less free, are then *stationary*; they can, however, be *thrown off*.

In such an instance the bullet has not acted alone, as in a contact fracture or in perforation of only one bony wall. The splinters it has torn off at the aperture of entry, the subdivided splinters close to the track to which the bullet

has communicated part of its active power, the fragments of the bullet which may have broken in pieces, have all acted as *secondary projectiles*. These last, propelled towards the bony aperture of exit in a more or less irregular manner, have increased the damage, and have given rise in some cases to a fracture feeling like a *bag of nuts*; even in some instances the seat of fracture has been freed from splinters (*focus swept away*, bullet fired from a very short distance—Fig. 11, 5).

Grooves.—In frequency they come after perforations.

They are more or less deep furrows in which one might accommodate a quarter, a half, even three-quarters of the diameter of the bullet; if deeper, the groove would become a perforation.

Grooves generally affect but a very small extent the transverse diameter of the bone. We must differentiate the grooves of the ridges from those of the body of the diaphyses.

Grooves of the Sides and of the Ridges of the Bone.—When the anterior ridge of the tibia, the sides of the same bone, the edges of the inferior extremity of the humerus, the linea aspera, the sharp edges of the radius or of the ulna, are indented, the indentation is sometimes distinct and isolated, sometimes it is accompanied by a transverse or an oblique fracture (Fig. 12).

Grooves on the Body of the Diaphyses.—They have a close relationship to the types of contact fractures we have described, especially to the first and the fourth (type with large splinters, the cuneiform V-shaped type).

As the bone, in the tangential contact that precedes the abrasion causing a groove, cannot have received a shock from active force as intense as the one it would experience when struck point-blank, which would lead to perforation, the *groove may generally be placed in the type in which there is little or but slight comminution*. This is an important fact.

It results from this that a great many grooves exist without any solution of continuity of the bone. Undoubtedly we may see rather shallow grooves of the diaphyses which consist of abrasions without fissures, but this is exceptional, and usually a fracture by contact accompanies the grooving of the bone.

When the bullet has bored in the body of the bone a rather deep track, it has not only indicated the limits of one or two large splinters, the lines of whose fissures join the big fissure of the wall perpendicular to the track of the bullet (*opposite fissure*), but also it has brought about, *symmetrically at its point*, a short *symmetrical longitudinal fissure*, and in the centre of this subdivision of splinters, in the centre of this secondary splinter, which to all intents and purposes is adherent, the bullet has travelled, piercing a narrow track in its passage.

In complete perforations the shape of the bullet is altered; it subdivides if it is provided with a covering. As we have before pointed out, it changes many of the splinters into secondary projectiles, which increase in number, and *by their comminution* extend the field of damage. In such a case there is no change of shape of the bullet, the reduction of the splinters into fragments is shown by their transformation *into dust*, which is gently projected into the soft parts.

Fracture by groove can be distinguished from the multiplicity of fractures through perforation by its *invariable simplicity*.

Splinters are pieces of bone whose limits depend on the projectile; they are connected with the foci of the fractures, and may be divided into *free* and *adherent*.

I. FREE SPLINTERS.—The smallest of these may only be represented by a kind of glazed bone-dust, resulting from the first hard, bony layer met with by the projectile. They are found lying around the *aperture of entry* into the bone.

Most free splinters come from the bony aperture of exit.

With them are sometimes found splinters that have been *set free* from the lateral walls where large splinters have been subdivided.

These free splinters, therefore, cannot exist in contact fractures or in incomplete perforations. This is an important dictum which surgeons should bear in mind.

The higher the velocity of the projectile causing them, the shorter they are. *In the great majority of cases they correspond, as we have before remarked, to the MUSCULO-CUTANEOUS CANAL of exit in which the bullet has left them.*

We must not forget that this musculo-cutaneous canal extends from the aperture of exit in the bone to the aperture of exit in the skin. It would be useless, and also incomprehensible, to search for these free splinters anywhere else in cases that have been wounded by ordinary rifle-fire.

The greater the velocity of the projectile, and also the more the fracture shows comminution, the farther these splinters will be from the aperture of exit in the bone.

When the velocity is excessive, free splinters are no longer carried along, but are *violently thrown out* in the form of a sheaf. They no longer have any exact situation, they bury themselves in the soft parts at a more or less long distance from the track, and some of them break out of the limb through numerous separate orifices.

2. ADHERENT SPLINTERS.—These correspond to the parts of the bony cylinder that the projectile has not touched.

Free splinters are short, adherent splinters are 4, 6, 8, 10, and even 20 centimetres long.

A large splinter is never a free splinter, but always an adherent splinter.

Their *dimensions*, like their *number*, are *inversely in proportion to the velocity* of the projectile. The less the velocity, the larger the adherent splinters and the less their number, and inversely.

The firmness of their adhesions also depends on the

velocity of the bullet. The less the latter, the firmer the former.

The *size* and *extent* of these splinters are in close relationship to the wounded bone. On the femur and the tibia they are often enormous; they decrease in size on the humerus, the clavicle, the bones of the forearm, and the metacarpal and metatarsal bones.

The direction taken by the bullet has also, in this connection, a certain importance. A bullet, the direction of which is nearly that of the axis of the bone, or follows it (enfilading fire), gives rise to longer adherent splinters than one that strikes perpendicularly.

The Osseous Focus.—From what has already been said, it is seen that the osseous focus of fracture by firearms presents, in the large majority of cases, *two fragmentary extremities moulded into the form of a wedge*: a SHARP wedge (contact fractures), a BLUNTED wedge (perforations); *also invariably adherent splinters* (all fractures), *often free splinters* (perforations).

Splinters increase the size of the focus by 4 to 20 centimetres, habitually by 6 to 8 centimetres. Only in a *cleared-out focus* (excessive velocity) is there loss of substance, and even then it is very trifling, because it is entirely derived from the splinters. The length of the bone is not obviously diminished. Even in these cases the total loss of substance, especially when considered from the point of view of the two cuneiform fragments, the upper and the lower, does not exceed, in spite of appearances, 2 centimetres.

Notwithstanding this damage done to the bone, even when there is a great deal of comminution, the soft parts have suffered the more injury; but we know how easily they undergo repair.

As a general rule, *the higher the velocity of the projectile, the more limited in length is the fracture, but at the same time it is more comminuted.*

This is a most important fact which we include amongst the many others we have stated. On the battlefield it affords a key to the nature, the importance, the intricacy of the assistance we have to render in cases of fracture.

The focus shows a difference according as *the bone has not sustained a solution of continuity*, or, on the contrary, according as *its continuity is interrupted*. It also shows a difference according as (1) the focus is simple, *without splinters*; (2) or simple with stationary *splinters that have not been displaced*; (3) or simple with *splinters that have been displaced and thrown out*.

In the first case the *canal of exit* in the soft parts is narrow, it turns on itself and has no tendency to infection; in the second case it is *widely open*, much *contused* and *bleeding*; in the third case it may reach the dimensions of the thumb and even more, it may admit several fingers held close together, even the whole hand. It is much inflamed.

If the focus of a fracture by firearms is comminuted, *this does not indicate that there is any solution of continuity of the bone itself*. In this connection fractures caused by firearms differ entirely from the fractures seen in ordinary practice in which comminution is always accompanied by solution of continuity.

Diagnosis of Osseous Lesions of the Diaphyses.

The diagnosis should rest on two points: (1) *General diagnosis of the osseous lesion*; (2) *diagnosis of the group and of the variety*.

I. GENERAL DIAGNOSIS.—*Pain, loss of all power in the limb, change in its length or in its shape, abnormal mobility*, all these points can be of use to us in fractures by firearms, as they are in ordinary fractures, in establishing a general diagnosis; but as many of these signs very often are wanting, we are obliged to look for others. The following are the signs

we consider of the greatest importance. Radiography has given them a place in the absolute front rank :

They are: *Shock* (comminuted and very comminuted fractures).

Pain evoked by pressure at a distance or on the supposed line of the fissures.

Angular prominence of the *terminal extremity of the large splinters*, easily felt in the superficial foci (tibia, ulna, clavicle), and sometimes in bones situated more deeply, even in the femur.

Position of the wounds in *direct* relation to the superficial bones (hand, foot, tibia, ulna, clavicle).

The relation of the track in the soft parts to the position of the bones.

The enlarged dimensions of the aperture of exit in the skin and in the clothing *compared with the aperture of entry* (short and middle range firing).

The spread-out *form* of certain orifices made by soft lead bullets.

Swelling, profuse hæmorrhage (the bone becoming a regular enormous collection of blood). This sign has not been sufficiently dwelt upon.

Escape of small oily drops (comminuted fractures of the big long bones).

The *presence of free splinters* in the canal of exit, at the level of the cutaneous orifice, or that of the clothes. This is a favourable sign.

A *special change of shape of the projectile* (lateral change of shape, bending back of the point), even when the aperture of entry shows from its appearance and its dimensions that the bullet has entered from point-blank firing, and had not been deflected nor had its shape altered.

Extensive crepitation, which is obtained by bringing the splinters together ; or *localized crepitation*, obtained by slight compression exercised in the direction of the aperture of

exit in the bone. These are quite harmless proceedings, very different to the highly reprehensible plan of seeking for crepitation by moving the whole of the bone, or by rotating the fragments ; this, indeed, is still worse, for this rotation easily renders complete an incomplete fracture, and gives rise to displacements which are difficult to correct.

These, then, were the signs we brought forward. They well maintain their value, and very often the military surgeon is unable to obtain others. Under favourable conditions, at the rear, radiography, the generalization of which becomes more and more necessary, much simplifies nowadays the general diagnosis.

When in doubt, we should act as if the fracture existed, and a more or less rapid examination, or one carried out subsequently, will either confirm or nullify the diagnosis.

2. DIAGNOSIS OF THE GROUP AND OF THE VARIETY—

(1) *Contact Fractures*.—We have given as principal signs of these fractures: *absence of aperture of exit, absence of very small oily drops, absence of free splinters in the canal of exit*, and, the best sign of all, *absence of perforation of the bone or of indentation, this having been proved by direct exploration*.

Here radiography has furnished precise indications and simplified research after these last two valuable signs. In fact, radiography has completed the clinical history of this group.

It shows in these contact fractures with large splinters—*The absence of splinters in the canal of exit*, and, above all, the PATHOGNOMONIC SIGN: the SHARP WEDGE OF THE TWO FRAGMENTS, upper and lower. *In no other kind of fracture caused by firearms is this sign to be found*.

(2) *Fractures by Perforation*.—Radiography settles the diagnosis of fractures by perforation of one wall of the bone.

Fractures by *perforation of the two walls of the bone* are recognized by the *rectilinear track in the axis of the bone*, by the *enlargement of the aperture of exit in the soft parts and in the*

clothes, by the presence of free splinters close to the cutaneous aperture of exit or else in the track of exit, by multiple orifices (explosive fire), by the change in shape of the point of the bullet, by splitting up of those bullets that have an envelope, by the localized crepitation in the focus of free splinters near the aperture of exit in the bone.

Thanks to these signs, the diagnosis of the lesion is generally easy. Radiography has made it still easier by disclosing (1) when there is no solution of continuity, the ROUNDED OR OVAL PERFORATION the diaphysis has sustained in the first wall that has been pierced, the more irregular but as easily demonstrated loss of substance in the second wall; (2) when there is solution of continuity, and even considerable displacement of the fragments, *the INDENTATION presented by the superior and inferior cuneiform fragments*; finally (3) in both cases *the PRESENCE OF NUMEROUS FREE SPLINTERS, either lying in the canal of exit or moved into a new position.*

(3) *Fracture by Groove.*—These fractures were very difficult to diagnose before the advent of radiography.

The circular nature of the track, occasionally the slight change of shape of the bullet (lateral parts and apex), the small free splinters in the canal of the wound, and especially the verification by the finger of a peripheric osseous groove, were the signs met with.

Radiography renders the FOLLOWING PATHOGNOMONIC SIGN perfectly clear: PERIPHERIC INDENTATION in the osseous track of hard lead bullets with an envelope (German and Austrian bullets). These tracks are rendered evident by small seed-like particles of lead when the bullet has become separated from its covering.

COMMUNITION is easily recognized. It is shown—(1) By *multiplied* loud, fine crepitation of free splinters, very different with regard to sensation and to sound from the extensive crepitation, more muffled and not multiplied, caused by the friction of the long adherent splinters.

(2) By the presence of a large number of splinters. We must also remember that in war surgery grave comminution and a solution of continuity are not synonymous.

Not only has radiography thrown light on the general diagnosis of these fractures, and allowed us to establish the diagnosis of the different groups, but every day it enables us to identify metallic foreign bodies, whole bullets that have lost their shape or become subdivided, and have been arrested in the osseous focus or in the neighbouring soft parts after having caused the fracture of the diaphysis.

We have already described many of these changes of shape, but in doing so we always had before our eyes the changes of shape that result from contact with hard soil before reaching the human body. Now we have to deal only with those that result from contact with bone.

Changes of Shape in Bullets that have struck Bones.—1. *Soft lead* bullets that have caused FRACTURES BY CONTACT are *flattened out*, and often take on the shape of the bones they have struck. According to the bone it has reached, the bullet is *flattened* or *concave*.

2. It is the same thing with hardened lead bullets that have an envelope. The change of shape consists especially in *flattening of the apex*, with or without separation from the envelope; but in these cases, again, the surface is *flat* or *concave*.

3. With bullets composed of one piece, such as the D bullet, the change of shape is insignificant.

In PERFORATIONS, both *soft lead* bullets and *hardened lead* bullets with an envelope become *flattened*, are *compressed*, and become bent from the apex to the base. The flattened surface of the apex is rendered irregular. The increase of diameter, consequent on the compression, results in enlargement of the bony aperture of exit, in the liberation of more splinters, and also in enlargement of the aperture of exit in the soft parts.

Though less marked, the changes of shape in the D bullet are analogous, but do not present any notable irregularity in the surface of the turned-back apex.

With GROOVES, the changes in the shape of the bullets are insignificant.

Foreign Bodies derived from the Clothes.—Diagnosis of foreign bodies derived from the clothes is rendered certain by inspection of the clothes which at the *aperture of entry* show loss of substance, and indicate the number and the dimensions of the pads, consisting of pieces of clothing, that are in the wound. *The surgeon should never forget to make this examination.* The enlarged aspect of the *aperture of entry* will ALONE determine the *probability of the sojourn of these infecting bodies* in the focus; on the other hand, increase in size of the *apertures of exit* is a sign that makes us presume the existence of a lesion of bone.

Prognosis, Progress, Evolution.

One of the most precise, as well as one of the most comforting, data that has been furnished us during the wars that took place at the end of last century and at the beginning of this is the fall of the percentage in the prognosis of fractures. The mortality oscillated between one-fifth and one-half, and the usual treatment was amputation. Nowadays, the smaller diameter of the bullets, the much less frequent occurrence of infection, together with smaller apertures, and the less common movements of pieces of clothing to various parts of the wound, quicker first aid, and the application of modern dressings, have not only modified the prognosis, but also the progress and ultimate result of fractures. At Karbine, amongst 2,845 cases of fracture, there were 39 deaths.

With *pointed bullets* that have not been deflected, progress is aseptic or very slightly septic.

Some fractures may heal like an ordinary simple fracture,

but this is rare. Many heal after insignificant suppuration, without the slightest doubt occurring as to the advisability of preserving the free splinters, whose ablation up to quite recently was regarded as a dogma.

In a large number of cases it is after a rapid, slight suppuration, and the removal of these splinters, if their presence really cannot be tolerated, that a cure is obtained. The bone retains its length, and its shape is soon restored; the joints rapidly regain their mobility. Badly formed callus would point to incompetence on the part of those who have treated the fracture. What we have described is the usual course of these traumatisms: slight and calm reaction, very soon arrested in cases of fracture caused by *pointed bullets*.

The foci of very comminuted fractures, of those produced by *deflected bullets*, by *bullets from shrapnel* or *shell splinters*, are seats of infection from the very beginning, and contain remnants of clothing which in themselves are infectious to the highest degree; these foci undergo sharper reaction and present more abundant suppuration, complicated by purulent outshoots. Sacrifice of the free splinters then rapidly becomes a necessity, and the utility of such a measure is proved by diminution of these symptoms so soon as the removal of these bodies is effected and the focus carefully disinfected, especially by the use of hydrogen peroxide, of 5 per cent. solutions of carbolic acid, of 10 per cent. chloride or permanganate solutions, but, above all, by pure hydrogen peroxide. Afterwards all will go on well, provided the wounded man is in the hands of a skilled surgeon.

However, the foregoing description cannot make us forget that much delayed dressing, the presence of unsuspected foreign bodies, and unskilled care of the wounded man, render the lesion liable to dangerous suppuration. Peripheral suppuration then becomes extensive, it reaches the

focus, the fissures, the multiple subperiosteal seats of separation; the free splinters play the part of foreign bodies, adherent splinters become free, and if the wounded man does not rapidly succumb to diffuse suppuration or to osteomyelitis, these complications, either the one or the other, in addition to the extremities of the fragments that have become sequestra, maintain persistent fistulæ and tedious suppuration.

It may be stated, and more especially with regard to soldiers with fractures, that the fate of these men depends more or less on the skill of those who treat them.

These cases should always be put under a surgeon who has acquired a certain reputation.

Extensively comminuted fractures are not as a rule more serious than fractures of a less complicated type, nor is their treatment more difficult, this being contrary to what might be conjectured in the absence of precise, if tardy, observations. We have even remarked a fact which seems paradoxical, that comminuted fractures—that is to say, those with very subdivided lateral splinters—present in young, well-fed men who have not suffered many hardships, and who are well cared for, particularly favourable conditions towards consolidation. This may be explained by pointing out that through the lines of fissure, much multiplied in these cases, the osteogenetic cells of the periosteum proliferate in larger numbers, and on to a greater number of points, than in fractures of a simpler type, and one is quite surprised to observe in a very short time exuberances of callus, which, moreover, are very quickly reduced to a definite formation.

Immediate or Late Complications. — 1. *Primary hæmorrhage*, although it may not come from a large vessel, is frequent in fractures of the large long bones. Plugging of the wound is often necessitated. But plugging has its serious disadvantages. If it is maintained for too long a time, a

few days, it prevents the wound getting rid of its excreta, and leads very often to *diffuse, putrid, or gangrenous inflammation*. This was proved in Manchuria, and also during the Balkan War. Everything must be done to prevent the recurrence of a similar experience.

2. *Gangrene*.—Nowadays we constantly hear it repeated that gangrene is an infection. Almost all existence is denied to *traumatic gangrene*, and we seem nearly to have forgotten the form of gangrene which is the result of great constriction, exercised by the apparatus put on to facilitate the patient's transport. We are wrong. All this exists. Traumatic gangrene is undeniable; gangrene by compression, resulting from mechanical arterial anæmia (garrot), must not be forgotten. The garrot stops arterial hæmorrhage; its object has been carried out. Excellent! But if the instrument is kept on beyond the exact time necessary to obtain this result, and on a limb the circulation in which is already imperilled by the presence of the arterial lesion, gangrene is quickly brought about. An apparatus may admirably retain bandages and dressing in place during transport, well and good, but it must be watched during the transport, and the transport must not last too long, or gangrene will appear.

Both traumatic gangrene and gangrene by compression are seen in these fractures. These complications nearly always come on from the second to the fifth day. We have seen most regrettable cases of this kind. Under these circumstances amputation is necessary, except when the gangrene is only partial.

3. *Foreign Bodies*.—We return to the subject merely to call attention to their frequency, to stigmatize the bad surgery of extracting them too soon and under defective surrounding conditions, *when it is a question of rifle bullets*.

Shrapnel bullets and shell splinters should be removed during the first regular dressing.

4. *Suppuration*.—It originates nearly always in the neighbourhood of the focus occupied by splinters, and from here its greatest diffusion is carried on. Issue should be given to the pus by *large incisions*, which, in principle, should correspond to the *aperture of exit*. Suppuration rapidly appears, generally during the first eight days.

In wounds by shrapnel, shell splinters, and deflected bullets, suppuration is habitual; therefore, to provide against such an accident, *wounded men suffering from any of these traumatisms should not be carried long distances at a stretch*, but should undergo successive evacuation of the pus as we have suggested, and *as soon as possible they should be placed under the supervision and treatment of a surgeon*.

5. *Osteomyelitis*.—Up to the time of recent campaigns, osteomyelitis was the most frequent and the most serious complication of osseous lesions caused by firearms. Let us at once state that it has become relatively rare.

Insufficient and unsuitable food, overcrowding, lack of proper and regular treatment, all these prepare the soil for infection.

Osteomyelitis in most cases shows itself about a week after the traumatism, often during the first fifteen days, by the advent of fever, prostration, sharp pain when the medullary canal is not open. The limb is very swollen, œdematous, red, hard, and feeling like wood. On deep palpation it is very difficult to identify sub-periosteal collections. In the focus of a fracture widely open, the periosteum is easily separated from the bone, and a red, mushroom-like bud is seen coming out of the medullary canal. The general signs are those of typhus affections and of purulent or putrid infection.

The subacute or chronic form presents very extensive thermic oscillations, slight pain, a similar hard puffiness, similar collections of pus, similar sub-periosteal and deep suppuration, and later on articular and parenchymatous

pains and swellings, symptomatic of metastatic collections (shoulder, knee, lungs, liver, kidneys).

Cure can only possibly be obtained by very active treatment, which includes sub-periosteal, deep, and rapid incisions, antiseptic washing out, the use of iodoform gauze; the internal remedy is sulphate of quinine in large doses (A. Guerin). If no success is obtained by these means, we must trephine the medullary canal, if it is not already open; if it is open, it must be scraped out, or disarticulation performed.

Treatment of Fractures of the Diaphysis caused by Firearms.

Conservatism is the rule in the treatment of these fractures. This is a precept which ought to be written in big letters at the door of every sanitary establishment.

Conservatism includes—(1) *Immobilization of the limb*; (2) *reduction of the fracture and maintaining it in position after reduction*; (3) *dressing the wound*; (4) *consecutive care and nursing*.

1. Immobilization.—Immobilization differs according to where the wounded man is found.

(a) On the *battlefield*, and during the transport of the patient to the ambulance, immobilization is obtained by temporary apparatus constructed of what the soldier has on his person, or of parts of his equipment or of his kit, and also of the materials carried by the stretcher-bearers or by the ambulance men.

For the *upper limb*, a handkerchief, a scarf, the lappet of the overcoat raised up and fixed to the shoulder (Delorme), will support the forearm; the neck-cloth (French soldiers) or the neck comforters now in use (English soldiers), first spread out and then rolled to form a bandage, will fix the humerus.

For the *lower limb*, the blanket, the rolled canvas of the

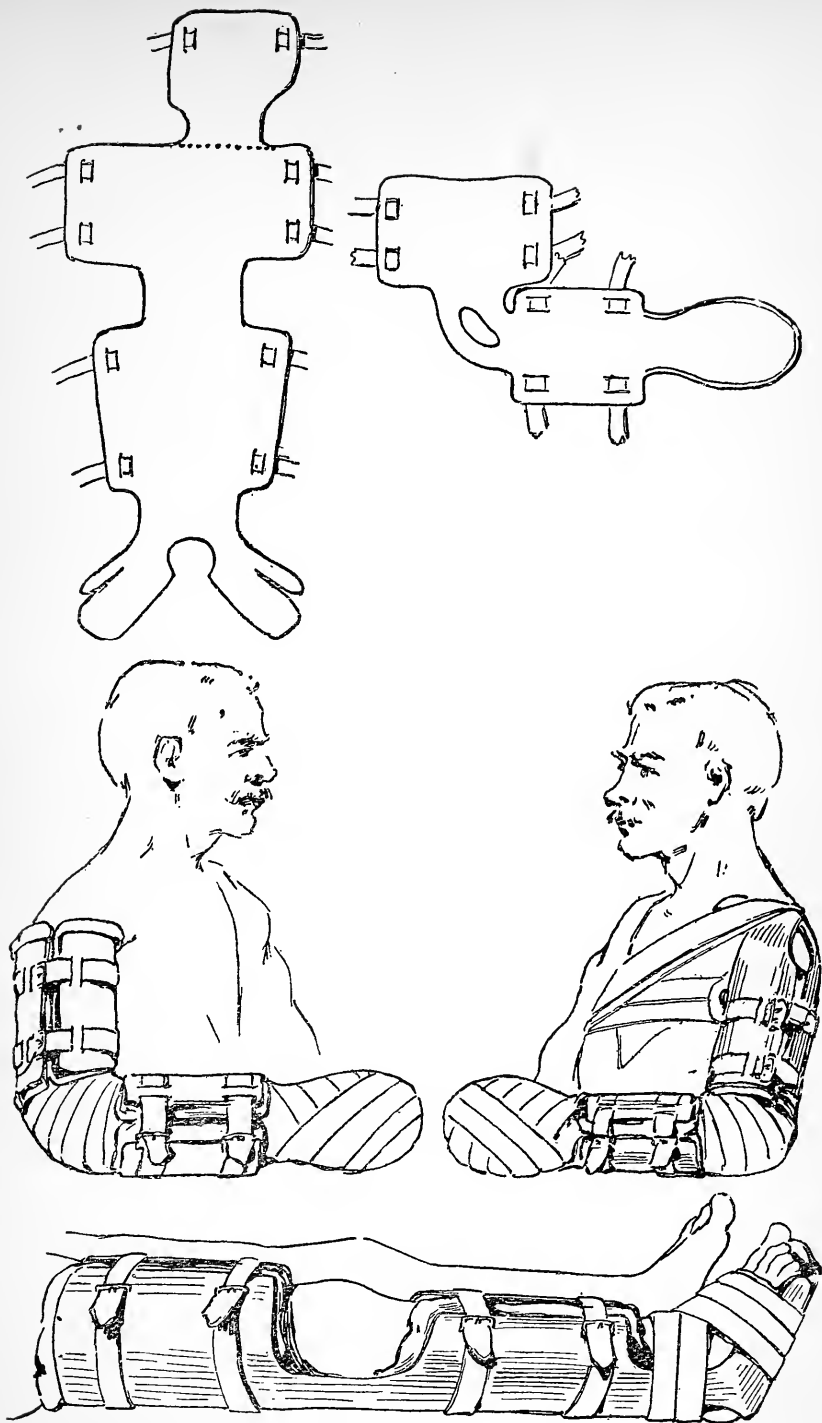


FIG. 13.—DELORME'S VALVULAR METALLIC GUTTER SPLINTS FOR FRACTURE OF THE DIAPHYSIS AND FOR ARTICULAR LESIONS OF THE UPPER AND LOWER LIMBS.

portable tent (French soldiers). The rifle kept in place by straps or belts, whose use has been so much recommended, will be replaced by *fixing the HEALTHY limb against the wounded limb*, keeping both in position by bandages *above and below the knee and on a level with the instep*.

(b) At the movable or fixed ambulance, the same methods should be employed, together with the many varieties of combined bandages, simple splints, and iron wire gutter apparatus, all of which are carried by the various ambulances, and approach more or less to the final apparatus.

These apparatus must realize the conditions on which we have laid stress: *simple construction, capacity for quick application, sufficient strength to keep the parts reduced and well together*.

We cannot too highly recommend the employment of the straw apparatus of Paré and Larrey, small trusses held together at certain intervals by twine; these apparatus are both stiff, flexible, and elastic, and are quite capable of maintaining the parts in their proper position; besides, they are easily prepared beforehand. They should be surrounded by a clean, thick piece of linen, and fixed on the limb over the clothes.

Apparatus for Transport.—In many fractures the patient should not be transported. These are cases in which the fracture presents *a grave solution of continuity complicated by hæmorrhage, by foreign bodies, or by comminution*. Fractures of the thigh, particularly, are amongst those that should be treated on the spot. In some cases, however, transport is an absolute, though hard, necessity. On the other hand, there is nothing to prevent the transport of many others, especially of those with fractures of the upper limb, but always on the understanding that the apparatus which holds the parts in position be appropriate and properly applied.

As the apparatus made use of must, in principle, be

stowed in the transport waggons of the ambulance service, they should not be very weighty. They should also be simple in construction, easily and quickly applied, and should insure the holding of the parts very exactly in position; in fact, they must be *removable, yet irremovable* (Delorme).

Innumerable have been the apparatus proposed; many of them have found a place in our waggons, such as apparatus of *pierced tin-plate, wooden splints, splints composed of a network of iron wire, rolls of metallic cloth*. They are all useful, strictly speaking, in dealing with the upper limbs whose fractures are more often without displacement.

Mayor's *iron wire gutter apparatus* is heavy and cumbersome; it takes up a great deal of room in the waggons, necessitates a large amount of material for padding, and does not immobilize properly. The drawbacks are well known. Why, then, is this apparatus still used? The occasion has now come for it to be definitely abandoned.

Plaster apparatus and splints are a long time getting dry, and their application is very slow and tedious; the plaster used is not always of good quality; they are not sufficiently strong and firm to be utilized during transport unless they are strengthened in some way; moreover, they labour under the very serious disadvantages of being irremovable, of not yielding to the swelling of the limb, which may undergo rapid and great dilatation, and this may give rise to gangrene. Therefore plaster apparatus are condemned by most army surgeons.

De Moy's *gutter splint* with valves would be excellent, were it not so expensive, and if it were impermeable. Its principle is very good. Sarrazin's *hollowed apparatus in metallic network with valves* is too complicated, and its storage is difficult.

The *zinc gutter splints* should be preferred. The metal is very malleable, and does not become oxidized; the cost of

the apparatus is small. For the upper limb, the model of Champenois has given proof of its utility. That of Hennequin transformed into a zinc apparatus is a little complicated with regard to transport, and the extension it is supposed to produce should not be relied on. The apparatus of Raoult-Deslonchamps are excellent in common fractures, for the treatment of which they were originally constructed. However, they do not allow of easy supervision of the limb, nor of easy renewal of the dressings. Struck by these desiderata, we have utilized some of the apparatus from the lower limb in constructing for the upper limb models which are accepted everywhere, and have their place in our ambulance supplies.

The Minister of War has just had these models forwarded to all our ambulances, whether in the front or in the rear.

Their storage is easy, as they are carried in superposed sheets of metal; they take up but very little room; they are very easily moulded to the limbs with the employment of a minimum of material, and even without any padding; they serve equally for either limb; they can be applied rapidly, thanks to their system of fixing, and, with the help of their valves, they render very easy both the supervision of the limb and the application of dressings. Why should our interest in these apparatus, on account of our having given them birth, prevent us from expressing our candid opinion and stating all the good that is thought of them? Facts speak for themselves. These apparatus have unquestionably shown themselves to be superior to any others, and deserve to be placed in the first rank of methods of immobilization both during transport and during the final treatment.

Definitive Apparatus.—We expect these apparatus, employed in the rear, to carry out the following points: (1) *Suitable immobilization of the fracture*; (2) *to allow proper supervision of the limb*; and (3) *easy application of dressings*.

Plaster apparatus, those for continuous extension, the

gutter splints of metallic network, are easy to apply, but very deficient with regard to retaining the fracture in position; they are preferred by many surgeons who are accustomed to use them. None of these apparatus allow easy supervision of the limb, nor especially the easy renewal of the dressings, coaptation of the splinters, and mobilization of the articulations. They are very inferior to the gutter splints with valves, that we can hardly recommend too much.

2. Reduction and keeping in Place of the Fracture

—In ordinary fractures reduction is an important procedure, because the external violence has nearly always caused great displacement, which itself is facilitated by the form of the fracture. In fractures by firearms it is not at all the same thing. In the upper limb displacement is very often absent, and is generally of little importance; in the lower limb it is likewise very often absent, excepting, however, in the thigh, where abduction and external rotation of the limb seem to be the rule.

A long time ago we drew attention to the fact that in fractures by firearms reduction following the axis of the limb was not the last word, but that it was necessary to combine with it *coaptation of the large splinters, their tight junction with the extremities of the fragments to which they must correspond*. It is first by manual pressure, and afterwards by pressure exercised with pads of cotton-wool placed laterally, that these results are obtained.

This pressure should be made in a perpendicular direction to the track of the projectile. Very often it is indispensable. It reduces the dimensions of the focus of the fracture, contributes to more complete and firmer coaptation, and allows us to obtain a more regular callus.

3. Dressing the Wound.

—In administering first aid, and even during the first few moments at the ambulance, the fracture will be immobilized, and the wound dressed

without removal of the patient's clothes. We should content ourselves with cutting the latter so as to form kinds of shutters, without, however, destroying the orifices already made. The first dressing will be applied over the parts uncovered by the cuts we have made in the garments.

At the ambulance this provisional dressing will be replaced by a complete dressing, after thorough asepsis of the wound and its neighbourhood has been obtained by the use of iodine. The wound will then be covered with the usual dry hospital dressing. Damp or wet dressings must be banished.

Formerly we were taught that, at the ambulance, removal of free splinters, either by enlargement of the wound or by slitting any constricting tissues, should precede the application of the dressings. Nowadays it is considered better to leave these splinters alone; but they have to be removed should suppuration come on in the wound.

Antisepsis of the infected foci should be secured (see suppuration). Washing with peroxide of hydrogen, with solution of carbolic acid (5 per cent.) or with ether, touching with chloride of zinc solution (1 per cent.) or with iodine, iodoform gauze dressing, etc., will then be very useful.

Suppuration necessitates incisions, followed by drainage. In making these incisions, we should give preference to the aperture and the canal of exit; it is here we shall find splinters and irritating foreign bodies. We must not hesitate to make free and extensive incisions.

Other incisions should be made so far as possible to follow the classical incisions for the ligature of arteries.

A practice, in all ways most regrettable, and which we thought had been definitively condemned, for it undoubtedly is by all those who are familiar with the requirements of war surgery, is one that consists in introducing into the canal of the wound an aseptic or antiseptic gauze or other drain that blocks up the opening. This proceeding is still

employed in the present day by skilled surgeons, and even by some who have a big name. We cannot possibly condemn it sufficiently. We cannot now return to the arguments, to the long discussions that have continued for so long a time on "drains and tents," from Paré to the present day. The subject is exhausted, opinion is laid down. The practice is a mistake—a most pernicious mistake. The Russian surgeons during the Manchurian War, and those who took part in the Balkan War, condemned its use after a trial that they bitterly regretted. Our wounded should not have to bear the disadvantages of fresh unjustifiable trials. Putting a drain into the focus of a fracture may be compared to shutting the wolf up in the sheepfold ; seriously, it is exposing the wounded man to most grave complications.

4. **Consecutive Care and Nursing.**—*Large and irregular pieces of callus* were rather frequent in the old days. Nowadays they are far less common. In most cases they indicate incapacity of surgical treatment.

Pseudo-arthroses are less seen since we have more respected the adherent splinters, which were condemned to be partly sacrificed at a time when the removal of the free splinters was recommended.

Painful callus is connected either with compression of nerve-trunks that have been surrounded by callus, with irritation set up by foreign bodies, or with osteitis. In fractures of the humerus, the musculo-spiral nerve is particularly predisposed to compression.

Foreign bodies, whose situation is easily made out, are removed nowadays without hesitation and without much damage.

Persistent *osteitic foci* necessitate gouging and scraping.

Nowadays, when the vital question no longer comes into play, and when the treatment of fractures has become much easier, we must endeavour to attain perfection in our definite results,

The use of mineral waters is quite indicated after the fracture is consolidated. Massage, and methodical movement of the joints, especially mechano-therapy, become a necessity. Bourbonne-les-Bains, Dax, Aix, and specially Vichy, whose mechano-therapeutic installation is admirable, will render great help in the treatment of the sequelæ of fractures. So soon as their fractures are consolidated, *the patients should be sent to such establishments.*

Resection of the Diaphyses.—This is a very old operation, which consisted, in fractures by firearms, *in removal of all the splinters, both adherent and free, and resection of the cuneiform extremities of the fragments.* This operation necessitated a tremendous amount of damage to the parts, prolonged the cure, promoted pseudo-arthritis, and brought in its train severe functional weakening. It has been abandoned. It gave lamentable results during the American War of Secession and during the German wars.

Amputation.—Amputation should be reserved primarily for large traumatisms of bone, with great destruction of the soft parts and *recognized* gangrene; consecutively, it may be forced on us by persistent suppuration, extensive chronic osteitis. Besides, it must remain, without the shadow of a doubt, in the surgeon's opinion as the only possible alternative.

CHAPTER VIII

LESIONS OF THE ARTICULATIONS

IN lesions of the joints we may include—*Periarticular, or non-penetrating, wounds; simple penetrating wounds; penetrating wounds with osseous lesions.*

Periarticular Wounds.—They have the same characteristics as wounds of the soft parts of all regions. The only general peculiarities that deserve to be noticed are—(1) those that concern the opening of tendinous sheaths or of periarticular serous bursæ which may convey the idea of a penetrating lesion, whilst in reality the soft parts only are affected; and (2) the danger of hæmorrhage in regions where the anastomotic circles are more especially developed. Let us finally draw attention, with regard to periarticular wounds, to certain lesions of the bony apophyses that do not penetrate the articulation. *The present bullets do not make contour wounds.*

Simple Penetrating Wounds.—These are penetrations of the synovial membrane without osseous lesions. They are rare, and are only seen in the shoulder and knee-joints. In the shoulder because here the loose capsule may leave, for the passage of projectiles, a certain interval between the glenoid cavity and the head of the humerus; in the knee on account of the great extent of the synovial cul-de-sac under the quadriceps extensor.

Diagnosis is difficult in the first case, easy in the second. Prognosis and treatment are about the same as for wounds with osseous lesions.

Penetrating Wounds with Lesions of the Epiphyses.—On cartilage projectiles give rise to *contusions*, *erosions*, and *abrasions*.

On the real epiphysis bullets cause *contusions*, *depressions*, *furrows*, *grooves*, *incomplete or cul-de-sac perforations*, *total perforations forming setons*, either superficial or deep, and *abrasions*.

THE FURROWS and GROOVES are clean, no fissures radiating from them.

THE INCOMPLETE PERFORATIONS have orifices and tracks of smaller dimensions than the diameter of the bullet. Lines of fissure are rare.

TOTAL PERFORATIONS are nearly always simple. When they are peripheral, the compact outer wall of the epiphysis is divided into subperiosteal fragments, which, when pressed upon, crepitate.

The *aperture of entry* is clean, and its dimensions are equal to those of the bullet, but are inferior or superior according as the velocity of the bullet was average, small, or great. This aperture is rounded or oval, sometimes blocked up by the periosteum, which is fissured, but not perforated, where it seems to be punched out; or sometimes it is masked by the thick synovial membrane to such an extent that the aperture can no longer be found on the dead body. Occasionally it is surrounded by minute splinters coming from the external compact table.

The *aperture of exit* is larger; it is irregular, lined by splinters, that are few in number, narrow, triangular, or rectangular, often adherent, opening like shutters. Its dimensions but little exceed those of the bullet (8 to 9 millimetres).

The track is regular, and either cylindrical or conical. Fissures, when they exist, are generally under the cartilage or the periosteum; they do not gape. They may be absent, or, on the contrary, be deep and branching. The more the tissue of the epiphysis is resistant (trochlea of the humerus,

condyle), the more the division is complete, the easier is comminution of the articular fragments.

The track is free of small remains of splinters.

Such are the simple lesions. In their vicinity complex ones are found, but in truth more rarely. The head of the bone is separated in the joint without splintering, divided into fragments, which are more sedentary than propelled in various directions, as they are kept together by the capsule and the corresponding articular surface. It is a remarkable fact that in these cases capsular fragments and those of the soft parts are most often not in connection with the bony traumatism; the capsule is preserved, and may even be crossed in a linear manner. The narrowness of the capsular lesions and the slight traumatisms produced by the present bullets explain to a great extent the favourable evolution of these wounds.

Such are the lesions seen on the undoubtedly epiphysial portion of the osseous extremity.

When the bullet penetrates at the level of the growing cartilage, it gives rise to lesions both of the epiphysis and of the diaphysis: a clear aperture of entry, an aperture of exit with splinters, and long fissures that radiate in the articulation and above it.

Again, we see these same lesions when the bullet keeps away from the growing cartilage, but then the fissures, though in the articulation, do not radiate below this cartilage.

Finally, in real joint lesions the *damage is generally limited*, the splinters and the fragments are few in number, adherent and kept in their place by a capsule which is but little open; *solutions of continuity of the limb are unimportant and rare*. Epiphysial lesions are therefore, as to their extent both in length and in breadth, very different from lesions of the diaphysis, and we may often regard them in the light of simple fractures,

Sometimes we have to deal with ABRASIONS.

The damage done by large pieces of shell is very different, both as regards extent and complexity, but it takes effect much more often on the soft parts than on the articulation itself. When the bones are implicated, if the joint is at the same time widely opened, we generally see the same type of lesion as with bullets.

General Consideration of the Types of Articular Fractures by Projectiles.—We have shown that these types are dominated by three conditions, the most important

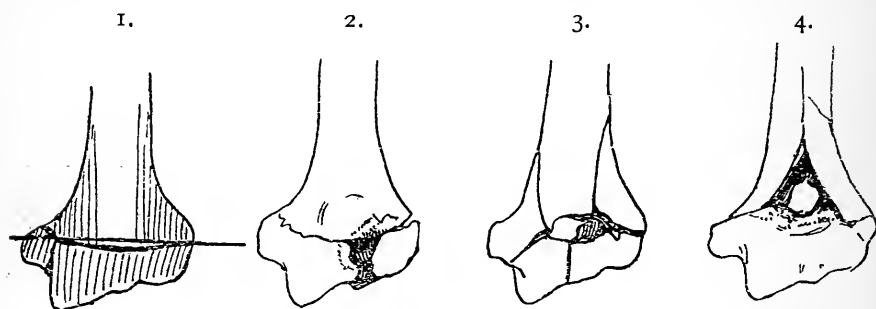


FIG. 14.

1. Epitrochlear-epicondylar line following that of the growth cartilage.
2. Subjacent lesion, or lesion of the growth cartilage (limited lesion).
3. Lesion corresponding to the line of the cartilage (lesion of the epiphysal-diaphysal type).
4. Superjacent lesion to the growth cartilage (lesion of the diaphysal type).

of which are the two first: *the part hit, the architectural constitution of the bone, the velocity of the bullet or the range distance.*

1. *The Part Hit.*—Bullets that reach the bone at the same point always produce identical or analogous lesions. Therefore, when we are well up in our pathological anatomy, we can affirm that such and such a lesion exists in a wounded man.

The important point for us to fix in an articulation is the line of the growing cartilage. Beneath this is the real epiphysal tissue, more or less spongy, with short trabeculæ.

Here the bullet produces a *special* lesion, *epiphysial*. Above this the tissue of the epiphysis and of the diaphysis, or of the diaphysis alone, of different constitution, presents lesions that are also different, and offer the type both of the *epiphysis* and of the *diaphysis*. Higher up towards the diaphysis the lesion is a lesion of the *diaphysis*.

2. *Architectural Constitution*.—The spongy tissue or articular bulb, subjacent to the line of the growing cartilage, shows localized but not radiating lesions. The subjacent tissue becomes perforated and fissured, and, as the architectural fibres become shorter as we approach the margins of the bone, the fissures will be all the shorter in proportion as the lesion will be more peripheral. For each articulation the fissures take the directions forced on them by the disposition of the architectural fibres.

3. *The Velocity of the Bullet* fixes, not the osseous type or its radiations, but the state of comminution. The greater the velocity, the more in general is the type one of comminution. This is specially remarkable in those lesions implicating the epiphysis and the diaphysis. The diameter of the bullet also plays a certain part. The larger it is, the velocity being equal, the more the comminution.

DIAGNOSIS.—When the osseous lesions are very comminuted and accompanied by the signs of grave fractures (change of shape of the limb, abnormal mobility, crepitation), the diagnosis is evident; but nearly always, with limited lesions and slight reaction, it is less easy to establish. Yet even in these cases it is quite possible to be certain.

The pain is not at all characteristic, *functional impotence* is an uncertain sign. Wounded men who have perforations of the large articulations still manage to move the joints. *Discharge of synovia* is frequently absent on account of the narrowness of the capsule wounds.

The following furnish valuable indications: *Enlargement of the aperture of exit* in short distance lesions affecting the

epiphysis and the diaphysis; *bone-dust* found in the track or in the secretions from the wound; the *very fine furrows or scratches* seen on the bullet when it has been arrested in the limb. The clearest signs are derived from *the relation of the external wounds to the region occupied by the articulation, rapid hæmorrhage, arthritis*, the indications given by *radiography*.

As modern bullets do not as a rule deviate in going through bony extremities, the position of the apertures and their relations to the joint furnish one of the most reliable signs. We may call it pathognomonic when the articulation is superficial.

Not only do these relations of the track to the joint determine the general diagnosis, but they allow us also to establish the differential diagnosis between a lesion of the *epiphysis, one of the epiphysis and diaphysis, and one of the diaphysis alone*.

Radiography does not give us in bony lesions of joints the striking and nearly always constant pictures that it furnishes in lesions of the diaphysis. However, radiographic indications are of great value. Lesions of the epiphysis and diaphysis are often found out by this means, and very often an educated eye will recognize a clean perforation of the epiphysis or a furrow—that is to say, the simplest lesions. More complex damage, such as the presence of fragments, is easily reproduced by radiography.

If, of all the signs, the most simple, the most practical, the most valuable, is the one furnished by the *relations of the wounds to the articulation*, yet we must remember that, to reap the full advantage from it, we must take into account the position the wounded man occupied at the moment of the traumatism.

Progress, Prognosis — Formerly wounds of the articulations were particularly serious. Infection was habitual. After a few days of relative quiet the joint became swollen, painful,

and tense; temperature rose, suppuration supervened, the joint soon was full of pus, which became metastatic, either through mechanical means or through the spread of infection. If the case did not come under the care of a prudent surgeon, who would decide to pursue the pus by means of large incisions, to secure free drainage, and to prevent its return by the use of topics, the wounded man succumbed to purulent infection.

Things have very much changed; but it must not be imagined that simple evolution, often aseptic, of the joints that have been penetrated, with slight reaction and trifling serous or sero-purulent excretion, is to be considered the rule without any exceptions. Prognosis of a bullet wound of an articulation should always be cautious, therefore its treatment ought always to be in the hands of a capable surgeon.

Articulations are not exclusively traversed by pointed bullets, that rarely carry infecting foreign bodies with them; joints are also penetrated by deflected bullets, shrapnel bullets, shell fragments. In such cases we must expect the appearance of arthritis, with which we must contend by employing appropriate and very active treatment.

Treatment.—*Conservative treatment is indispensable in the very large majority—we may even say in the sum total—of articular lesions produced by bullets.*

In narrow, non-infected wounds, the result of bullets fired point-blank, we must be satisfied with simple dressing of the apertures and immobilization. Even if there is no bony solution of continuity, immobilization must be carried out. We must abstain from any exploration. In general there are no splinters to remove.

In larger traumatism, produced by deflected bullets, shrapnel bullets, etc., wounds that are often contaminated, the articulation should be washed out (solution of carbolic acid, 20 per cent.; hydrogen peroxide in small quantities),

after removal of all constriction by incisions; the wound is then drained. The wounded man should be kept under supervision. All transport is to be avoided, especially if the wound is seated in the lower limb and in a big joint. Shrapnel bullets and shell fragments remaining in the articulation should be removed as early as possible, but invariably with aseptic precautions.

Arthritis that has undergone suppuration necessitates prompt arthrotomy. Resection incisions should be made use of. It is preferable to make double openings rather than to limit ourselves to one incision. In these cases ablation of the free splinters is imperatively called for. If, in spite of the arthrotomy, of incisions, and of intermittent interarticular washing out, suppuration persists in abundance and in a threatening manner, we must have recourse to an *atypical resection*, followed by prolonged immobilization of the articulation to avoid subsequent deformity.

Amputation will be an extreme and exceptional measure, only to be utilized in threatening septicæmic symptoms.

Immediate immobilization of the articulation is procured by methods that may be at hand to treat fracture of the diaphysis.

The surgeon will endeavour to obtain immobilization during regular treatment by *apparatus which leave the articulation free*; these render easy the supervision of the wound and the application of the dressings, and allow him to make incisions which burrowing of the pus might necessitate.

To attain this immobilization we cannot speak too highly of our *hollowed out gutter splints with valves* that fulfil all these conditions.

As a general rule, moderate compression brought about by cotton-wool applied to the joint is very useful to prevent puffiness of, or effusion into, the articulation.

Passive movement must be begun very early. Naturally the nature of the lesions will here be taken into considera-

tion. Generally this most necessary part of the treatment is not commenced soon enough, hence stiffness of the joint and most regrettable functional loss of power.

Lesions of the Flat Bones and of the Short Bones.

Flat Bones.—Flat bones—cranial, innominate, scapula—when hit by projectiles, present *contusions*, linear, radiated, *concentric fissures*, occurring either on the side first hit, or on the opposite side, or even on both sides, with or without displacement of splinters from the internal face of the bone; *indentations*, *furrows*, and *grooves* which are limited to the track of the projectile, or complicated by the presence of more or less depressed splinters from the internal table; finally, both *incomplete* and *complete perforations*.

The aperture of entry of these perforations is nearly always clean and regular, having dimensions below or above the diametrical dimensions of the projectile. The track is regular. The aperture of exit is a little larger, surrounded by quadrilateral, triangular, or lunated splinters more or less adherent, varying in size from a few millimetres to 1 or 2 centimetres. Their number varies from two or three to ten, even to fifteen. Generally they are in small numbers.

Direct fissures often unite by the shortest track the two orifices of a through-and-through perforation; there are frequently concentric fissures in addition. The more compact the bone, the more this spreading is seen. It is more observed in the cranial bones than in the os innominatum. The lesions are generally circumscribed, and complete fracture of a flat bone is impossible when it has been hit perpendicularly to its surface. Under such conditions the os innominatum cannot be fractured with solution of continuity by a bullet.

Let us draw attention to the furrows on the edges and to the abrasions of the apophyses.

Bullets that reach the flat bones at a *tangent* give rise to losses of substance which extend to the whole track, and which are prolonged both upwards and downwards by numerous but adherent splinters (scapula). In these cases solutions of continuity may be seen.

The fragments of large projectiles produce fissures, furrows, and extensive perforations, even sometimes abrasions.

Short Bones.—The short bones (wrist, tarsus, etc.), present *contusions, furrows, perforations, crushing*.

The orifices of the usual perforations are narrow, sometimes without fissures. The fissures are generally short. Comminution and also solutions of continuity are rare.

Splinters are small, adherent, and few in number; free splinters are represented by a kind of bony dust. To sum up, the damage is limited and very trifling.

CHAPTER IX

GENERAL COMPLICATIONS OCCURRING IN WOUNDS BY FIREARMS

Immediate Phenomena.—We have already spoken of complications occurring through *hæmorrhage*, through *traumatism of the nerves*, and through *foreign bodies*. We have now to consider—*pain*, *nervous delirium*, *local and general stupor (shock)*, *tetanus*, *hospital gangrene*, *ordinary gangrene*, *localized or diffuse infection*, *pyæmia*.

Pain.—As a general rule bullet wounds give rise to very little immediate pain, even when they involve nerves. A great many men hardly feel they have been wounded. Pain does not stop the soldier's dash. We all remember the history of a company whose men in charging the enemy only noticed their wounds through seeing the blood that flowed from them.

The torn wounds caused by shell fragments are generally painful.

Nervous Delirium.—This is an erethismic form of shock. It must not be confounded with alcoholic or insane delirium.

Wounded men, either singly or collectively, are attacked with violent agitation, with a kind of fury or of rage; they perform the most extraordinary movements, talk volubly, relate with great vivacity the incidents of the action in which they have been engaged, weep, develop excessive

affectionate feelings, and at the same time their general sensibility is deadened.

Reeb, Poncet, and Gross, at Strasburg, and I myself at Saint-Quentin, have all observed veritable localized epidemics of this delirium.

The delirium may end in collapse. It has sometimes a very harmful effect on the progress of the wounds.

Local and General Stupor.—Local stupor is marked by the insensibility of the wound. A wounded man can finish the detachment of his own limb, which is nearly separated, without showing any pain. We have seen this happen several times. The temperature is lowered, the muscles are soft, flabby, dry, not injected nor secreting. After some days reaction is complete, or gangrene supervenes.

With regard to this complication, which is seen almost exclusively in wounds from large projectiles or their fragments, the pathogeny is obscure; lesion of the nerves here probably plays an important part. One fact is well established, that surgical intervention undertaken in tissues affected with local stupor, and on wounded men with general stupor, does not show good results. Gangrene is a frequent ending of local stupor.

Treatment consists in employing generous stimulation both general and local, in wrapping the wound in cotton-wool, and in the temporary rejection of antiseptics.

General stupor is the result of an abrupt concussion communicated to the cerebro-spinal axis by a violent shock, either direct or transmitted through a large diaphysis, the seat of a grave fracture (shell explosions, abrasions of limbs by bulky fragments of big projectiles).

Dulness of the senses and intellect; the eyes fixed and haggard; pupils very dilated; motionless features; the body covered with cold sweat; slow, sighing, weak breathing; from time to time extensive inspiratory and expiratory movements; small, irregular pulse; vomiting;

incontinence both of fæces and of urine; lowering of the temperature; wounds dry; insensibility; intellect often retained, but showing dulness; coma—such are the clinical characteristics of general stupor.

General stupor may terminate rapidly in death; it may, however, disappear, or become mitigated in a few hours. It has been said that *any wounded man in a state of stupor whose temperature sinks below 36° C. will die.*

All intervention excepting ligature of bleeding arteries is contra-indicated. Chloroform is dangerous (Crimea). We should have recourse to the horizontal position, to local (heat) and general stimulants, to subcutaneous injections of ether, of caffen, or of camphorated oil.

Tetanus.—Tetanus, whose frequency is variable, though it was great in former times (12 per cent., one in seventy-nine during the wars of the First Empire), was no longer met with in the Transvaal War. In the Russo-Japanese War Holbeck observed it once in 100 wounded men. In more than 4,000 patients in this war we only saw three or four cases. The number, however, is rapidly increasing.

Narrow wounds, especially those of the lower limbs, contaminated by the soil, infected by pieces of clothing, exposed to the risks of suppuration, exposure of the soldier to cold, all predispose to tetanus. In theory, tetanus can be contagious, but practically it is not.

It may appear a few moments or some hours after the wound, generally from the sixth to the eighth day, occasionally later.

Its superacute form is mortal in a few days; in its chronic or slight forms cure is possible (31 per cent.).

Let us rapidly recall its symptomatology: pain, spasms on a level with the wound (four-fifths of the cases), then very soon trismus, stiffness of the nape of the neck, dysphagia, risus sardonicus, muscular contractions coming on in fits, and set up by the slightest excitement; remis-

sions alternating with the crises; atypical fever; intelligence remains intact.

Facial contraction and paralysis in cephalic tetanus (wounds of the head). In the grave form, with its rapid appearance (fifth day), we see the same beginning, the same crises, but they are longer and more violent. The temperature is raised.

The treatment consists, with the idea of prevention, of relieving all constriction by incisions, of removal of foreign bodies (shrapnel bullets and fragments of shell), of rapid draining of the infected wounds, of disinfection with hydrogen peroxide, iodine, and solutions of carbolic acid. The conditions under which the first-aid stations work on the field of battle render very difficult and eventual any general employment of antitetanic serum, even for its upholders. Isolation is to be recommended in order to insure tranquillity and to avoid disturbing the other patients, rather than as a preventive measure.

Against confirmed tetanus: free incisions, washing out with antiseptics, more especially with hydrogen peroxide, removal of foreign bodies, rest, opium, chloral and bromide of potassium in large doses, sudorifics, very much prolonged baths. Subcutaneous or spinal antitetanic serotherapy has not given any convincing results. Spinal injections of from 2 to 6 c.c. of a solution of sulphate of magnesium, 25 in 100 every day during five or six days, are sedative. They act specially in relieving painful contractions. It has been advised to combine these injections with others of serum in large doses.

Hospital Gangrene.--This complication, formerly frequent, has nowadays almost disappeared. It is very contagious, epidemic, and caused by Vincent's bacillus; it may invade any wound, recent or old.

In the slight form, a veritable *diphtheria* of wounds, it shows itself by the development, on unhealthy looking

fleshy granulations, of a grey opaline membrane, or a dry buffy coat, analogous to the coating produced on a wound by the employment of iodoform. Violent pain, spreading and phagedenic advance of the malady. No fever.

In the *grave, pulpy form*, there is seen a thick, putrid, pultaceous buffy coat, having the colour of putty. Very violent pain, with fever and solid œdema. Abundant foetid ichorous secretion, superacute phagedena. In 1870 we sometimes saw the gluteal region and the popliteal region become sphacelated in a few hours.

Formerly the prognosis was very serious. In the slight form, touching with lemon-juice, with iodine (Italy, 1870-71 war), immersions in permanganate of potassium solution, 1 in 1,000, dressings with hydrogen peroxide and with Labarraque's liquid.

In the grave form, touching with perchloride of iron; this is very painful, but very efficacious. Actual cautery on the surface.

Rapid and absolute isolation of the patient, to whom a special staff should be attached and told off.

Suppuration, Phlegmon.—Abundant suppuration is very frequent after wounds caused by deflected bullets, by shrapnel bullets, or shell fragments, and wounds complicated by pieces of clothing. Therefore we should always carefully *examine the clothing*, and look for any loss of substance at the apertures of entry, and more especially in the fractures themselves.

When there is extensive loss of substance in the clothing, it is prudent, as a preventive measure, to *relieve all constriction* at the orifice of the wound, and, still better, to immediately search for the projectile, which very often would tend to prevent the exit of the pieces of clothing, the primary sources of the infection.

On the advent of suppuration we should make incisions; the focus should be cleaned out with hot water, the wall of

the abscess touched with iodine or permanganate of potassium (1 in 1,000). Washing out should be done with a strong solution of carbolic acid (5 per cent.), or with hydrogen peroxide. The latter is excellent. It is not irritating, and cleanses all cavities (30 to 50 c.c. each time). *Permanganate and hydrogen peroxide should always be made use of in wounds that have been soiled by earth.*

Hydrogen peroxide, whilst being the specific topic for emphysematous gangrene, is besides indicated as an antiseptic in the treatment of streptococcal (phlegmon, lymphangitis, erysipelas) and putrid infections.

Surgical Erysipelas.—It was formerly very frequent. It was seen during the Secession War (0·4 per cent.), in the Russo-Turkish Campaign (0·9 per cent.), rarely in the Manchurian War, often in the Thrace Campaign. Application of too irritating dressings, occlusion of wounds by plugging, both tend to encourage its appearance. Vexatious explorations open up a passage to streptococci.

The wound becomes dry during the progress of the lymphangitis. There is fever, and the general condition is bad. Diffuse abscesses, secondary hæmorrhage, and sphacelus, are among the consequences.

Gentle, moist, boric acid dressing, with iodine painting (Ferraton); quinine, alcohol, as internal treatment. Serum treatment is but little utilized; it may give rise to accidents. Isolation is important.

In cases of lymphangitis and of erysipelas, Souligoux first washes the limb, then rubs it with a soft brush, removes the soap with alcohol, and finally applies a dressing of cotton-wool soaked in ether, which is changed when necessary. He has nothing but praise for this treatment.

Pyæmia.—This is rare. We have already observed some cases of it during the present war following wounds by shell fragments.

1. In a SLIGHT form the wound is painful; some fever may

be noticed with sordes, also headache and depression. It lasts from eight to fifteen days (Ferraton).

2. SEPTICÆMIC FEVER (Ferraton).—Remittent fever without rigors ($38\cdot39^{\circ}$ C.), gastric troubles, dry tongue, dried-up wound, bad general condition, rapid and small pulse, frequent respiration, scanty and albuminous urine, nervous disturbances, both ataxic and adynamic, that in severe cases lead to death.

3. PYÆMIA.—Its appearance is encouraged by primary infection of the wounds (shrapnel, shell fragments), also by defective dressing, delay in opening collections of pus, tardy evacuation; intermittent fever, with great oscillations (39° to 40° C.), with severe rigors, fœtid secretion from the wound, which is covered with exudation; signs of phlebitis; serious general condition, cadaverous appearance, dry tongue, diarrhœa, dyspnœa, muttering delirium (Ferraton).

Metastatic abscesses, both articular and parenchymatous.

Preventive Treatment.—Regular dressings, immediate relieving of constrictions, disinfection of the wounds, and dressing only at long or relatively long intervals.

Crowding should be avoided, and isolation of those men already infected must be insisted upon.

When pyæmia is recognized as being present, antiseptic baths, washing out with solutions of carbolic acid or permanganate, or with hydrogen peroxide, touching with the chlorides. Tonics should be given, especially quinine in large doses (A. Guérin)—8 decigrammes, 1 gramme, 1·50 grammes per day (12 grains, $15\frac{1}{2}$ grains, 23 grains). Injections of nucleinate of sodium, fixation abscess, lavage of the blood.

Amputation is sometimes necessary, but it is always a proceeding of much gravity.

Emphysematous Gangrene.—Of great frequency in wars, especially at the commencement. It has already been seen in many forms, chiefly on German wounded who have

been abandoned. Surgeons should always be on the lookout for its appearance, because its progress is very rapid; also it necessitates very active treatment, and because of its dangers of contagion.

No wound is safe from it, but the wounds most exposed to it are those of shell fragments and of dangerous fractures.

Two forms are described—one makes rapid progress, but is *not fulminating*; the other is absolutely *fulminating*. In both varieties the same general symptoms are seen; the progress alone is different.

The symptoms are *pain, emphysematous swelling of the region, general disturbance*. The *pain* is *constant*; it is felt some hours before the swelling and the general disturbance, therefore it need not be taken into too great consideration.

It is *acute, violent, excessive, constricting*. Nearly all the patients ascribe it to the constriction of the apparatus or of the dressings, but if these are taken off it is found that swelling may not as yet exist.

This pain depresses and lowers the wounded man. It gives him the look of a person suffering from typhus or from cholera (sunken eyes, earthy complexion, etc.).

The œdematous *swelling* is hard, tense, white, then bronzed, showing brownish venous ramifications; phlyctenæ are seen in the vicinity of the wound, which has become dry. The swelling is *crepitant*. The development of gas is not only perceptible to the fingers, very often it can be *heard*. In a few hours the whole of a limb in fulminating cases may be invaded.

Sensibility in the affected limb is lost; the temperature is of average intensity (38° to 39°C.), or else is very high (40°C.), occasionally it is low (36°C.); rapid pulse; sighing respiration. The patient is perfectly indifferent to all that goes on around him, and dies quietly, sometimes suddenly. Such is the ordinary course of fulminating gangrene, but the description is not unique. In some cases general symptoms

predominate at first, on some occasions they are mitigated; sometimes the emphysema is a long time appearing, and remains localized for a certain period. This is a fortunate circumstance.

Very marked *general symptoms, violent pain, rapid gaseous development*, are not found in gangrene by compression. In gangrene by *contusion*, gaseous development is again found, but it is less rapid, and such well-marked general phenomena are not seen.

Emphysematous gangrene commences in the wound; gangrene by contusion commences at the terminal extremity of the limb. Gangrene through lesion of the vessels, when it gives rise to gaseous development, shows the same invading progress, but this, again, commences at the *terminal extremity of the limb*.

The gaseous development is not always due to a septic vibrio. Emphysematous gangrene, if we take into account the prodromal period, shows itself *before the suppuration of the wound* (Trifaud).

Preventive Treatment.—Strict disinfection of soiled wounds, isolation of the affected patients, severe precautions with regard to special preservation (amputated limbs taken away at once, all soiled linen, dressings, etc., destroyed, instruments disinfected by flame or by boiling), to avoid contagion.

In cases of acknowledged emphysematous gangrene we should employ at first free incisions of the wound, followed by extensive washing out with hydrogen peroxide. If permanganate of potassium, 4 in 1,000, be associated with the hydrogen peroxide, a much more intense liberation of oxygen is obtained. At the same time *intracellular injections* should be utilized.

Against the fulminating processus we should oppose a *barrier of hydrogen peroxide* administered in hypodermic injections at the point where the œdema and the gaseous crepitation is arrested. The injections will be renewed

morning and evening, or several times during the day. With Pravaz's or Dieulafoy's needle a double circle of injections should be made. Hydrogen peroxide is injected by half Pravaz syringefuls, 20 or 30 for the leg, 30 or 40 for the thigh, and these injections are renewed.

If one is out of hydrogen peroxide, oxygen under pressure can be used, which can be introduced into the limb by insufflation through a Dieulafoy's needle that communicates with a reservoir through an india-rubber tube.

At various distances tension should be relieved by incisions made in the aponeurotic partitions, so as to prevent the excessive tension of the tissues dilated by the gas; this, if left unrelieved, will lead to compression of the vessels.

The whole treatment should be carried out with conviction.

Quick amputation, or rapid disarticulation in healthy tissues, are the last resources after failure of injections of hydrogen peroxide. Circular section. No sutures.

Alcohol, quinine, camphorated oil.

CHAPTER X

WOUNDS BY LARGE PROJECTILES AND THEIR FRAGMENTS

IF small shell fragments produce lesions more or less analogous to those of bullets, it is not at all the same thing with large fragments nor exceptionally with the entire projectile. In the soft parts these wounds show extensive and deep *contusions, crushing, contused lesions, tearing away of tissues.*

The *contusions* are of all degrees. In their highest degree of severity they are marked by extensive effusion of blood or of serum. When they take effect on the splanchnic organs, which themselves, however, have apparently not been touched by the projectile, we see deep and extensive attritions which formerly were attributed to the *wind of the projectile.*

The *contused wounds* are vast erosions, big furrows, large lesions forming a cul-de-sac, wounds with large pieces of tissue hanging from them, fimbriated, ecchymotic, contused in their depths; they are abrasions with torn surfaces and quivering and herniated muscles. Very frequently the wounds in their deep parts are complicated by metallic foreign bodies, by earth, by fragments of clothing. We have good reason to be surprised at the enormous size of some of the foreign bodies that are extracted. Otis speaks of a 12-pound shell lodged in the gluteal region; Constan of a shell fragment weighing 850 grammes lodged in the

thigh, into which it had penetrated through an opening only 4 centimetres in length.

Occasionally we observe widely gaping setons.

Large and average sized fragments of *armour-piercing shells* give rise to large slits, partial or total abrasions of the limbs; very different to the tearing away and crushing contusions brought about by large fragments of other shells. The cul-de-sac wounds of these armour-piercing shells are rarely deep; they are often complicated by pieces of clothing. Generally the orifice is clean. We still see total perforations with an irregular, big aperture of exit whose lips are everted.

By the side of these excessive disturbances let us remember, as a sort of antithesis, the ingraining of the integument, the small wounds, often very numerous, produced by the *metallic dust* of melinite shell, the cul-de-sac wounds with a very small orifice that harbour small shell-fragments at a depth varying from a few to 15 centimetres.

To return to the large fragments. Their contused wounds, often complicated by local numbness, foreign bodies, both metallic and derived from the clothing, bleed very slightly, but are doomed to suppuration, and threatened by grave complications (gangrene, tetanus).

Treatment.—Large traumatisms occurring in labouring men enable us in everyday practice to foresee the extreme limit to which we can push conservatism in the cases of soldiers wounded by big shell fragments.

In their treatment it has been proposed to utilize the method called "Reclus's packing." The following is the way in which it is applied:

The patient's state of prostration having been relieved by injections of normal saline, of caffeine, of ether, the wound itself and its diverticula are disinfected by a current of water at 60° C., which is at the same time antiseptic and hæmostatic. Clots of blood, free splinters,

and all tissue that has lost its vitality, are removed; the wound surface is wiped with a pad, which is soaked in a solution of permanganate of potassium; then we apply an ointment containing corrosive sublimate, salol, antipyrine, carbolic acid, iodoform, with vaseline for excipient.

The ointment should be covered with a thick layer of hydrophile cotton-wool and a muslin bandage.

To this local treatment Reclus added injections of normal saline with a dessertspoonful of brandy, injections of caffeine, etc.; a long interval should elapse before a change of dressing; it is removed in about the third week.

Irrigation with hot water has been retained, but the antiseptic packing has been replaced, after antiseptic washing with hydrogen peroxide, by a dressing, only changed at long intervals.

We do not think that this dressing with long intervals, after one or two cleansings with antiseptics, is preferable to the use of topics with a more persistent action.

If Reclus's dressing is considered complicated, we need only simplify it, but its general idea—(1) dressing rarely changed, (2) use of topical remedies with a persistent action—should be maintained. The treatment is not new; it forms part of our old and good traditions.

In 1870-71 we saw used for wounds rarely changed dressings of powdered charcoal, mixed with powder of cinchona and of camphor; later still, Lucas-Championnière advised in these cases the employment of antiseptic powders with a lasting action.

All these are treatments to be recommended.

CHAPTER XI

AMPUTATION

Indications.—*Immediate amputation is, so to speak, never indicated in traumatisms through bullets.*

It is only admissible in cases of confirmed gangrene.

In the most comminuted fractures, neither very extensive damage of the soft parts, nor an extreme condition of comminution of the diaphyses, nor supposed nor evident lesions of the large vessels, nor injury to important nerves, can be looked upon as indications for amputation.

Very great disturbances of the soft parts can be repaired; it is possible to obtain union in the bones, even when a fracture is comminuted; lesions of the large vessels are not always followed by gangrene, and we cannot be absolutely precise in laying down the exact nature of wounds of important nerves by bullets.

Immediate and atypical amputation can only be called for in cases of *complete smashing* or of *almost total tearing off of a limb by a big projectile or by a big fragment.*

Later on, amputation may be necessitated by—

1. *Confirmed traumatic gangrene.*
2. *Rapid extension of emphysematous gangrene, which is almost generalized in one limb.*
3. *Conditionally, by an enormous diffuse aneurysm, which threatens to rupture if the surgeon does not feel himself qualified to put on a direct ligature.*
4. *By very grave complications through suppuration, especially osteomyelitis.*

Amputation must not be carried out during the period of shock, by reason of its extreme gravity.

It should be carried out as soon as the indications for its performance are absolutely confirmed. The incisions should be made as low as possible.

Disarticulation is preferable to amputation when removal of the limb is rendered necessary by medullary lesions.

The circular method in cases of gangrene; in other cases the circular method and the method with square flaps should be preferred.

When there is danger of infection of the stump, the wound should be left open.

CHAPTER XII

WOUNDS OF THE SKULL AND BRAIN

INJURIES of the skull and brain occur very frequently. Their proportion is commonly said to be from 12 to 15 per cent. of the total number of injuries. More than half of the wounded succumb on the battlefield.

With the firing-line in sheltered trenches, these injuries increase in number ; but the total of cases seen at the ambulances remains about the same. Soldiers who receive these kinds of wounds rapidly succumb. .

Injuries of the Scalp.

The soft tissues (the scalp) covering the skull are bruised by bullets, furrowed, perforated as if by a seton, on the lateral parts. Shell fragments divide, perforate, or lacerate them often to a great extent ; sometimes it seems as if the wounded men had been scalped. Cold steel weapons may cut through the scalp in many places. Slightly compressive aseptic or antiseptic dressings will generally suffice to secure their healing. Their evolution is simple.

Wounds of the Skull and Brain.

When the skull is struck by a bullet, *contusions, cracks, and fissures, depressions, slight grazings, grooves, single perforations, double or through-and-through perforations* are observed.

CONTUSIONS, FISSURES, FRACTURES OF THE INNER TABLE, ETC.—*Contusions* are the results of tangential shock or of direct shock (low velocity). Sometimes they may be recognized by denudation of the bone; at other times they may only be suspected.

Cracks and *fissures* involve both tables of the skull or one table only. Those of the outer table are exceptionally met with (Delorme). Fissures of the inner table are linear, curved, circular-, oval-, radiant-, X- or T-shaped, and are accompanied by slight loosening of the dura mater. In general, in fissures of both tables, the fragments of the inner table are depressed. The diagnosis is effected by *de visu* verification of the fissures on the outer table. When we find these last, we may conclude that the inner table presents the same kind of lesion, but in a more serious form.

Depressions due to bullets are only exceptional.

GROOVES AND FURROWS.—Grooves and furrows occur frequently. In the least serious form they consist of superficial, canalicular abrasions, with very regular borders of the outer table or of the outer table and the diploë. These grooves specially extend over the comparatively flat surfaces of the skull.

Even when the lesion on the outer table appears of the most simple nature, it is in most cases complicated with splintered fragments of the inner table; these are free and pressed down on to the dura mater or on to the brain.

It is not impossible for the inner table to remain absolutely intact, as we have just seen in two cases in which it appeared very distinctly, uniformly smooth in appearance, at the bottom of the groove. When the groove includes *the whole thickness of the bony wall*, the resulting small splintered fragments are as a rule propelled rather towards the aperture of exit than towards the meninges and the brain.

SINGLE PERFORATIONS.—Single perforations, or perfora-

tions of one wall only, are comparatively rare; they especially occur when the projectile is fired point-blank from a long distance, or when the bullet has ricocheted. The aperture of entry is like a punched-out opening, circular or oval, its diameter being a little less than that of the projectile, with somewhat greater loss of substance towards the inner table. The bevelled surface of the inner table has supplied the few free or still adherent splinters, which have scarcely left the periphery of the gap in the bone.

Contusion of the nervous substance is less pronounced in the intracerebral track than in through-and-through perforations. The tunnelled cerebral wound hardly ever contains splinters; but if it does, they are small. The organic fragments, or the shreds of clothing that may be swept along, are small or absent; the bullet itself has lodged in some part of the cerebral substance.

In some instances the bullet becomes fixed against the internal part of the skull, at a point symmetrically opposite to the wound of entrance, bruising the bone, fissuring it on its outer table, or on both of its tables, or even limiting the focus of large splinters that prepared its exit.

DOUBLE PERFORATIONS.—Double or through-and-through perforations are the most common cranial lesions resulting from modern bullets, but they are seldom observed in the rear. They present circular- or oval-shaped apertures of entry like those of perforations of one wall—*i.e.*, bevelled at the expense of the inner table. As for the aperture of exit, on the table the bullet first passes through—*i.e.*, on the inner table—it is circular, regular in shape, cut as with a punch, and, on the outer table, the last one perforated, it is enlarged, bevelled, splintered, the splinters being adherent or loose. There is contusion of the intracerebral track for a short distance, or for a distance of several centimetres from it, according to the velocity of the bullet. The track contains loose splinters, disseminated in the cerebral substance, if the

wound had been received at long range with low velocity ; in the opposite case the free splinters are driven forward. At the aperture of entry the dura mater is torn and loosened ; at the exit it is perforated, but not loosened.

When the velocity of the bullet is *EXCESSIVE*, *the whole cerebral substance may be dilacerated*, and the radiated *fissures*, which were very limited when caused by long-range firing, are here very much *increased* in number and in extent. The aperture of exit is large, and from it flows a diffuent cerebral mass. This may be called the explosive lesion of firearms. With double perforations, survival is only possible when the firing has been from a long range, and the velocity of the bullet has been low.

TANGENTIAL PERFORATIONS.—This is a variety of cranial traumatism of which recent wars have shown the relative frequency. They are perforations the orifices of which are oblique and near together, preceded by a groove and joined together by numerous fissures, which form the limits of short and generally adherent splinters. The bullet has thrown off in its course a few free splinters, shreds of hair, and sometimes particles of headgear. The cerebral dilaceration is more superficial, less severe than in other perforations. Consequently these wounded are quite likely to recover. They, together with those suffering from grooves, present the most favourable cases, and also the ones that more particularly require surgical intervention.

Fissures complicating tangential perforations are more or less extensive and numerous ; they are circular, linear, or radiant, often uniting both apertures.

INJURIES FROM LARGE PROJECTILES.—*Shrapnel bullets* inflict injuries similar to those produced by rifle bullets. Contacts and single perforations are with them more frequent than double perforations. Grooves are very rare. The orifices of the perforations are a little larger than those of rifle bullets.

Large fragments of shells produce contusions, fissures, depressions, and especially dilacerations.

If the general features of cranial orifices are, so to speak, always the same, there is reason, from the point of view of symptomatology, as from that of prognosis, to distinguish the through-and-through perforations according to their *location*. We have sketched several groups of them that ought to be kept in view and better studied: the *antero-posterior* or *postero-anterior* perforations, fronto-occipital, fronto-temporal, fronto-parietal, parieto-occipital; *bilateral*, bitemporal, biparietal, bioccipital; the *perforations* that follow along a vertical or oblique plane, a line *from the vault to the base*, or *vice versa*.

Diagnosis.—The diagnosis of open cranio-encephalic wounds inflicted by projectiles is generally easy. *Discharge of cerebro-spinal fluid, loss of cranial tissue*—perceptible to the finger, sometimes visible—*issue of cerebral material from the aperture of exit, or from the aperture of entry, the direction followed by the missile, cerebral disturbances of deficit or of meningo-encephalic excitement*, are the general characteristics of through-and-through perforations, of single perforations, of grooves involving the whole thickness of the bones of the skull, accompanied by laceration of the dura mater.

Shallow grooves are recognized by an extensive *cranial depression* with sharp edges.

Pain, at first evoked by pressure of the finger along the fissures, and *pericranial swelling* denote the pressure and direction of fissures.

Contusions, cracks, and fissures, with or without depression of the inner table, are of delicate, uncertain diagnosis. The last will be suspected when the finger causes pain at a distance from the wound, and meningeal irritation points to a depression of the inner table (*pains and contraction on the side corresponding to the lesion*). As a rule, in these injuries direct exploration *must be avoided*. In case of doubt one is

to act as if the suspected lesion existed. Under conditions of absolute asepsis exploration of the wound, with the help of an incision or a freeing of the integuments from all constriction, may be warranted.

On the other hand, in the other varieties of injuries, particularly in furrows, grooves, perforation of a single wall, tangential perforations, double perforations, in which exploration helps to confirm a diagnosis which may require operative interference, *aseptic exploration is allowable* and often necessary.

Many of the wounded with cranio-cerebral traumatism, who get beyond the first-aid lines, surprise the surgeon by the absence or the attenuation of the symptoms they present. Under a small wound, whose edges are already adherent, that presents but slight suppuration, and that might be taken for a simple wound of the soft parts, the skull is found to be gouged out or perforated, and broken-down cerebral substance is seen. If the wound is slightly raised, it is due to a small cerebral hernia. These soldiers have often walked for a long distance. Nothing in their general appearance would lead one to believe they were suffering from a serious lesion; they talk, eat, they take their place by themselves, and cheerfully too, on the table for surgical dressing. However, if one is warned, in some we discover a certain amount of indifference, in others some want of intelligence. The absence of symptoms, the readiness with which their cranio-cerebral traumatism are mistaken for simple wounds, account in a great measure for their having been transported over long distances. We have already seen many of such unfortunate patients. The prognosis, so favourable at the beginning, deceived us in the same way that their diagnosis had already done.

The injuries of neutral cerebral zones (frontal region) may not be revealed by any symptoms. In general, how-

ever, in transverse *frontal perforations* we observe blindness, anosmia, strabismus.

In *parietal and temporal perforations*, disturbance in the mobility of the limbs and face, aphasia, cecity, visual disorder, are seen. But these symptoms may be absent or but little marked.

Occipital perforations may give rise to disturbance of sight and of equilibrium, to vertigo, to priapism.

Antero-posterior perforations often have very indistinct symptoms. *Vertical perforations* are nearly always rapidly fatal.

If in a patient with a great number of wounds we notice signs of *cerebral shock*, the disturbances in hearing, sight, sensation and motion, which may be also observed, are but transitory. Moderate or severe cerebral shock is mainly connected with the concussion between the skull and shell fragments.

Symptoms of *compression*: Disturbance in feeling, in motion, in the organs of sense, loss of corneal sensibility, mydriasis, stertorous respiration, coma, are only seen in depressed fractures due to large fragments of projectiles. In military cranial lesions, most of which are open, these symptoms are hardly ever connected with hæmorrhage; this is contrary to what occurs in ordinary practice.

The signs of *contusion* are deficit signs. They may be very obvious or almost absent.

The present campaign opens up to neurologists, as well as to physiologists and to French surgeons, a wide field of study which should not be lost, and to which, in the author's opinion, sufficient attention is not paid. Certain bullets make in the brain paths as clean and as simple as those produced in experiments on animals. We are too apt to forget that when these last were undertaken the object was to study a symptomatology and certain disturbances that are interpreted and sometimes shown by our wounded in quite a different manner.

Evolution.—With the present small perforations produced by rifle-bullets, aseptic evolution is far less rarely seen than in former times.

Professor Ferraton regards as closely connected with an attenuated infection, the early psychic accidents (maniacal excitement, which can be mistaken for alcoholic delirium) and other cerebral disturbances, which will be considered in another chapter (epilepsy, dementia, etc.).

It is infection (through hair, shreds of headgear, soiled bullets, irregular dressings, etc.) extending from light sup-puration and circumscribed meningo-encephalitis to generalized meningo-encephalitis, that makes these lesions so dangerous, and causes a mortality oscillating between 15 and 57 per cent.

Prognosis.—As a rule the prognosis of encephalic lesions is of the gravest. Most of the wounded die on the battle-field (from 40 to 55 per cent.), 26 to 28 per cent. succumb in the ambulances or in the hospitals.

The prognosis of *through-and-through* cranio-cerebral perforations is the most severe of all. Only those made by bullets of low velocity (small apertures) can be studied. The wounded who offer resistance to the first symptoms surprise the surgeon by the length of the track and the benignity of the sequelæ, but this cannot make us forget the large number of soldiers who perished shortly after their traumatism.

Recoveries from *single* perforations by bullets are less exceptional.

Of all the open lesions, *grooves are the less serious* when they are properly treated.

Non-penetrating wounds heal in most cases.

In lesions produced by bullets the prognosis is in general in close relationship to the velocity of the projectile and to the importance of the parts involved. Frontal wounds are the less severe. Extensive injuries from shell fragments

lead as a rule to immediate death. Penetrations from shrapnel are very grave (through the larger diameter of the projectile and foreign bodies).

The mortality would seem to be 1·7 per cent. for the non-infected (!!), and 41·8 per cent. for the infected wounds.

Among those that recover, one-fourth succumb to sequelæ, and at least one-half of the remainder are left permanently infirm.

Treatment.—Lesions of the skull and brain are, of all those involving the parenchymatous organs, the ones which are in the greatest need, according to some authorities, of surgical interference.

In their treatment it would be wise to keep within a margin of systematic abstention and systematic intervention.

Indications relating thereto may be summed up as follows :

1. *Contusions, cracks, and fissures require no primary intervention.* It is only in fissures complicated by depression of the inner table with meningeal or cerebral irritation (*pains and contractions on the same side as the lesion in cases of meningeal irritation ; pains and contractions on the opposite side in cases of cerebral irritation*) that trephining of the skull over the point of impact would be warranted.

2. *Depressed fractures* produced by large shell fragments, and giving rise to symptoms of compression, necessitate raising of the splinters, and not their removal. Trephining is here only a procedure to facilitate the task of the surgeon. The trephine must not be employed if the surgeon, without its use, can seize the splinter where it has passed between the fracture and the dura mater.

3. *Single perforations must be treated primarily by conservatism.* If by enlarging the cranial loss of substance with the gouge or the trephine free access is obtained to the loose splinters of the inner table, it must be remembered that these splin-

ters, not having been driven forward, are seldom irritating ; that, on the other hand, the surgeon who wishes to operate can do nothing to rid the brain of splinters lodged in the track, and that, moreover, his intervention would be blamable if he wished primarily and as a general rule to search for the bullet and to remove it. To open widely these wounds, which are generally not infected, is to open a door for infection and to risk cerebral hernia.

4. *Through-and-through perforation* must be treated without operation. In these grave lesions, to increase the cranial opening at the level of the bony aperture of entry would only facilitate the removal of the sedentary splinters of the first inner table, and could not insure either the removal of organic foreign bodies formed of shreds of clothing or of splinters thrown forward into the track or into its extremities. For the removal of the superficial splinters located near the orifice of exit of the second table the trephine would be useless, these splinters being either adherent, when they should be kept in place, or free—that is to say, easily extracted without trephining.

5. Grooves, cranial furrows, remain to be considered. Their treatment forms the triumph of operative surgery. Intervention here becomes a necessity ; it gives beneficial results when the irreparable loss of substance to which the skull is subjected is not excessive, and when it is limited to what is strictly necessary.

Here, as we have already seen, more or less numerous splinters derived from the inner table have been liberated ; often they have been depressed, driven into the cerebral substance. The encephalic focus is superficial, and is easy to clean. Therefore there is good reason for intervention ; but it must be remembered that the breach is long, and that one is liable to bring about very extensive and regrettable loss of cerebral substance if the opening be too freely enlarged. It is not the procedure of a true surgeon to willingly and

uselessly increase disturbances which in themselves are already severe.

These precepts differ from those of daily surgical practice as understood by many surgeons, who advise operation not only in cases of *well-authenticated bony lesions*, but also when these bony lesions are only *suspected*, they would trephine even in cases of cracks without depression.

Whatever the procedure followed in *rather important* cranio-encephalic traumatisms, the wounded men suffering from them *must not be transported to a great distance*. Transport is dangerous, nearly always fatal. Out of seventeen patients who had been trephined, observed by Deljalitzky during the Manchurian War, thirteen died during their transfer; the four others arrived at Karbine comatose.

Complications.—The principal *primary* complications of cranio-encephalic wounds produced by projectiles are—*Meningo-encephalitis, hernia of the brain, foreign bodies.*

MENINGO - ENCEPHALITIS, ABSCESS OF THE BRAIN.—Meningo-encephalitis, the most formidable complication of traumatisms of the brain, is less frequent nowadays than formerly. It appears from the *third* to the *sixth day*, nearly always in the *generalized* or *circumscribed* form.

Rise of temperature, violent headache, phenomena of cerebral excitement, are the first symptoms. The wounded man is irritable, cries out, grinds his teeth, struggles, tears away the dressings; slight twitching of the face muscles, general contractions, unequal pupils, nausea, vomiting, are noticed; secretion from the wound dries up, and, when the wound is rather large, *cerebral hernia* appears.

At the period of *crisis* there is delirium, also clonic spasms, localized or generalized convulsions; the *twitchings* become more or less *generalized*; the patient makes grimaces; the pulse is hard and slow.

Twenty-four hours to a few days after this *period of excitement* we arrive at the *period of paralysis*, characterized by

somnolence, coma, paralysis of the senses, cessation of muscular contraction. The wounded man passes away in a condition of collapse usually between the fourth to the eighth day after the outbreak.

Irritative and depressive symptoms may appear in turn ; at other times either irritative or depressive phenomena are predominant.

Localized cerebral infection, superficial or deep, like intracerebral abscess, is either of rapid or of slow apparition. They may appear several months after the traumatism. Violent pains, irritability of the wounded man, twitchings, disturbances of the depressive class, indications of cerebral compression, are the general signs to which sometimes are superadded symptoms of localization. If the dura-mater is exposed, it is deprived of its undulatory motion.

Cerebral abscesses are frequent after bullet wounds. They are early (two to fifteen days) or tardy (a few weeks to some months) (H. Billet).

From a curative point of view, we are still almost disarmed when dealing with generalized meningo-encephalitis (Billet). *Largely opening the skull with the toilet of the cerebral coverings* (Horsley), *trephining, with meningeal drainage* (Mignon, Poirier), are uncertain in their results.

Lumbar puncture (Chasteney de Giry, Meslier, Auvray), more simple in technique, is perhaps more worthy of recommendation, and should be systematically employed (Billet). It should be repeated every day, and even if necessary twice a day (Billet); at the same time free incisions should clear the wound, or wounds, of all constriction, with careful disinfection, and puncture of the cerebral substance should be resorted to in search of the abscess (tardy symptoms).

The *treatment should, above all, be preventive*. Cerebrospinal meningitis is especially observed in men with tangential wounds or lesions due to shrapnel bullets, and these

cases are precisely those in which primary intervention is justifiable (Billet). Puncture should be carried out from the appearance of the first symptoms. Symptoms which impel us to employ surgical intervention are fever, frequency of pulse, presence of microbes in the fluid obtained by lumbar puncture (meningitis). In abscess this fluid is not turbid, but clear (Auvray).

In cerebral abscess we must intervene when we see some signs of the necessity of doing so (hernia).

HERNIA OF THE BRAIN.—This is a very frequent complication, which occurs in two forms: *primarily*, from twenty-four to thirty-six hours after traumatism, as a diffuent prolapse of the brain, with either an almost normal aspect; in which splinters of bone are found, or, *consecutively*, as a mass, the size of a nut, a hen's egg, an orange, dark reddish in colour, turgid, fleshy, partly reducible, but whose reduction may bring on comatous or convulsive symptoms.

Hernia is generally the sign of the evolution of meningo-encephalitis or of a cerebral abscess.

It is *very frequently the regrettable consequence of the extensive cranial dilapidations caused by the surgeon.* Therefore it is a good reason to raise against systematic trephining (H. Billet).

Hernia of the brain is a very serious complication. During the recent wars the mortality fluctuated between 54 and 58 per cent. (Billet).

To hinder infection, to avoid large surgical losses of substance, constitute in these cases the basis of preventive therapeutics.

Ligature, excision, strong compression, are condemned. We must content ourselves with exercising slight compression, dressing at rare intervals, and carrying out a puncture, if we suspect an abscess; finally, we must treat the meningitis. Subsequently the surface of a granulating and irreducible hernia should be covered with skin.

FOREIGN BODIES.—The foreign bodies implicated in intracerebral tracks are projectiles (rifle bullets, entire or in fragments, changed in shape or deflected, shrapnel bullets, and especially shell fragments); in half of the cases they are shreds of headgear, pieces of hair, and projected splinters.

The presence of one single penetration is almost pathognomonic of the presence of a projectile, but radiography alone can establish both the general diagnosis and the localization.

Primarily, SYSTEMATIC ABSTENTION FROM SEARCHING FOR THE PROJECTILE IN INJURIES FROM RIFLE BULLETS SHOULD BE THE RULE.

Abstention from systematic search for intracerebral splinters should also be the general rule. It is impossible to discover their location; their removal would expose the patient to excessive damage, and might not be complete. Impossible also is the removal of shreds of headgear, the presence of which has been revealed by a loss of substance in the head-dress.

The present bullets are often tolerated. They may be extracted SUBSEQUENTLY, but only when their presence is unbearable. We are inclined to advise an early removal of shrapnel bullets and of shell fragments that carry with them and so often hold infecting foreign bodies, provided, however, these bullets and shell fragments have previously been carefully located by radiography.

Removal by forceps may give rise to further damage. For removing metallic foreign bodies we would advise the use of a curette mounted on a handle. This curette is similar to a urethral extractor scoop, and can be bent.

SYMPTOMS CONSECUTIVE TO TRAUMATISMS OF THE SKULL AND BRAIN.—Let us pass by adherent cicatrices, cranial losses of substance that are somewhat extensive and so difficult to repair with raised cicatrices, badly protecting the brain from noises that cause pain when they strike on it.

Solutions of continuity one is obliged to cover with india-rubber plates.

Cerebral disturbance consecutive to injuries of the skull and brain constitutes one of the most mournful pages in the history of these wounds. This disturbance is extremely frequent. Thus, among the considerable number of wounded in the Secession War, *only two presented no cerebral disturbance*. A VERY LARGE MAJORITY *of the men violently struck on the head in warfare are* BRAIN PATIENTS *constantly under the influence of extremely grave cerebral disease* (Lasègue), and who for this very reason have claims to the good-will and charity of the War Office authorities.

Another peculiarity in the history of these cases is that *these troubles very often appear at a remote date from the traumatism*.

The military surgeon should constantly bear in mind these data.

These troubles are of various kinds : (a) *Psychic*, (b) *sensitive* or (c) *sensorial*, (d) *motor*.

Billet, according to Holbeck, has established their proportion. It would be necessary, however, to complete on a larger basis the ratios observed up to the present time.

The most usual *psychic disorders* have to do with modifications of character : the various kinds of memory are diminished or abolished (*simple amnesia*, *retrograde amnesia*—that is to say, loss of remembrance of events that happened prior to the wound); they manifest themselves by all the varieties of insanity, mainly *melancholia* and *dipsomania*, *acute mania*, *general paralysis*. Medical men have wished to make predisposition play an important part in these manifestations. It would be more just and true to reduce this importance (Delorme). Besides, even if, with certain wounded, predisposition did exist, it should in no wise lessen their claims to a pension.

Violent and persistent *pains*, *vertigo*, either spontaneous or on the slightest inclination of the head, are usual.

Impairment of hearing, of sight; of taste, are very frequent.

Contractions, especially *epilepsy*, are very frequently observed.

Traumatic epilepsy seems specially to depend on two causes: inclusion of a projectile or of bony spiculæ in the brain, cerebral irritation caused by a cicatrix which creates an epileptogenic zone (Billet). It therefore seems that in these two categories of facts operative cure ought to be attempted in spite of reservations that might be made as to the therapeutic value of these interventions (excision of the cicatrix, removal of the foreign bodies).

In cases of Jacksonian epilepsy, operation seems more prejudicial than serviceable.

The failure of surgical intervention seems to be due to the fact that it is impossible to remove all cerebral cicatricial lesions and to prevent their return.

Deficit, consecutive, and motor troubles manifest themselves by more or less persistent paralysis.

LEGAL POSITION OF SOLDIERS WOUNDED IN THE SKULL AND BRAIN.—To the fourth class of infirmities that give a right to a pension, belong the wounded who present :

1. Complete hemiplegia or complete paraplegia of traumatic origin.

2. Grave deterioration of cerebral functions—loss of memory, of speech, imbecility, dementia, insanity, etc.—resulting from a wound of the head.

3. General paralysis, with incontinence.

The following wounded necessarily figure in the fifth class. Those presenting—

1. Incomplete hemiplegia or incomplete paraplegia.

2. General progressive paralysis at the critical stage.

3. Epilepsy, epileptiform fits, functional spasms resulting from a traumatism.

4. Paralysis of an important organ (muscles of the eye, etc.).

5. Extensive and deep cicatrix of the skull, with loss of substance of the pericranium and of the bones in their entire thickness.

In the sixth class we have the wounded who present :

A persistent fistula, the result of necrotic or carious periostitis.

CHAPTER XIII

WOUNDS OF THE FACE

THEY are as frequent as the wounds of the skull. Although several of the regions of the face may be injured simultaneously, distinction should be made between the *wounds of the nose, of the orbit and eye, of the ear, of the superior maxillary, of the mouth, of the inferior maxillary*, each of which should be studied separately. Rifle fire that hits this region is *antero-posterior, transverse, vertical*, sometimes direct, sometimes oblique.

Wounds of the Nose.—The nose when struck by a sword or a large shell fragment may be partially or entirely severed from the face, together with a part of the superior maxilla. Bullets indent it, or more commonly perforate it. The damage is generally limited. Struck by antero-posterior or lateral firing at a short distance, the nose may be divided into several parts or split up.

The wounds heal without complications. Hydrogen peroxide (diluted by half) is one of the best antiseptics for these lesions, which usually suppurate. Even when they are very bruised, *all osseous or cutaneous fragments must be carefully preserved*; they will be held in place by nasal tamponade.

In large traumatisms, autoplasty and prosthesis provide the surgeon with admirable expedients.

Wounds of the Orbit and of the Eye.—Direct lesions of the bones of the orbit are notches, indentations, perfora-

tions, with *short*, thin, and dry splinters. Indirect or extended lesions are fissures radiating from the base of the skull.

Bullets often pass through the orbit without touching the eye or the optic nerve. On other occasions this nerve, as well as the other nerves in its neighbourhood, is contused, indented, divided.

Rapid ecchymosis, palpebral swelling, occasionally exophthalmia, are the immediate signs of wounds of the orbit.

The evolution of these lesions is nearly always simple, and their dressing presents nothing particular. When infected, they may give rise to abscess of the orbit, and threaten the meninges.

An external incision gives issue to pus.

Of frequent occurrence, the *injuries of the eye* consist of *contusions*, with or without hernia of the iris, dislocation of the lens, detachment of the retina, tearing of the choroid, of slight or large *wounds*, of *perforations*, *abrasions*, *rupture*.

At first the diagnosis is either obvious or very obscure. In trying to localize it, one finds that functional troubles, diminution or loss of sight, can arise from very diverse causes.

Radiography will determine the presence and seat of metallic foreign bodies.

In some cases these wounds heal without complications; in others the cornea, the iris, the choroid, become inflamed. The vitreous becomes easily infected. Panophthalmia is common.

Sympathetic ophthalmia is frequent. It is one of the most serious complications of lesions of the eye. It appears sometimes very quickly, sometimes in the course of the year following the wound—a fact which must not be lost sight of by the skilful medical man.

Antiseptic dressings of iodoform ointment are used at

first; certain lesions of the cornea, the iris, the sclerotic, may need suturing. Immediate enucleation is the treatment of extreme irremediable wounds, or of those that are complicated by the presence of foreign bodies. It must not be forgotten that this is preferable to conservation by reason of its being less often followed by sympathetic troubles.

Wounds of the Ear.—They rarely are seen alone; in most cases they are accompanied by concomitant lesions of the skull and of the face; they result from antero-posterior and transverse firing.

In artillery fire and explosions, ruptures of the tympanum (oozing of blood from the ear), concussion of and hæmorrhage from the labyrinth, are by no means rare.

Bullets and shell fragments notch, perforate, partially destroy, the pinna; gouge out and penetrate into the bony auditory canal or the mastoid process; invade the petrous bone as far as the interior of the cranium, and gouge or perforate the petrous bone itself.

Wounds of the large vessels closely connected with the ear give rise to dangerous hæmorrhage (internal carotid, branches of the external carotid, internal jugular, transverse sinus); but even independently of any injury to these large vessels, external and buccal hæmorrhage is frequent. The loss of cerebro-spinal fluid, of broken-down cerebral pulp, implies some cerebral complication; lesions of the facial nerve, of the trigeminus, are revealed by their ordinary signs. Those of the facial are not rare.

Diminution or loss of hearing is nearly certain in deep wounds of the ear, and secondary psychic troubles occur pretty frequently. These wounds rarely remain aseptic; they nearly always suppurate, and the pus may burrow even into the neck.

Treatment at first comprises instillations of carbolized glycerine and iodoform or iodine, the introduction of a

drain of aseptic or iodoform gauze, and bucco-pharyngeal disinfection. No splinters should be extracted, excepting those that are free; removal of adherent splinters would render the patient liable to dangerous hæmorrhage.

Foreign bodies are subsequently taken away by the retro-auricular route after petro-mastoid clearing out.

Wounds of the Upper Maxillæ.—On their edges the upper maxillæ are notched; in their body they are perforated (bullets) or abraded with comminution (shell fragments), occasionally separated as a whole, and dislocated from the rest of the bones of the face, or separated one from the other in the middle line at the time they are perforated by bullets travelling with great velocity.

Injury of the alveolar border is complicated with dental traumatism, fractures, tearing out, with propulsions of the teeth.

The splinters are generally short.

Notwithstanding the communication of the osseous focus with the nasal fossæ and the mouth, the evolution of these wounds is usually benign, even when there is extensive loss of substance with large external lesions.

The prognosis of these injuries is in the main not serious, provided the surgeon secure buccal antisepsis, the danger lying in the continual dropping into the buccal cavity of septic products arising from the seat of the fracture.

Gargling or, better still, very frequent irrigations by large glassfuls during the first days, besides those taken immediately before any food or drink, are to be preferred to a drain of antiseptic gauze.

Hydrogen peroxide is excellent in these cases. In its absence we can employ potassium permanganate solution (1 in 4,000), boric or iodized solutions, even simple boiled water. Some wounded men are quite capable of doing their irrigation themselves both by day and by night.

The diet should be liquid, at least for the first days. The

liquid food should be introduced behind the dental arches through an india-rubber tube supplied with a small funnel.

A bandage to support the chin, ligation of the teeth, suturing, will all help to keep the loose fragments in place. Not one of these last should be sacrificed even if they are very loose. At the rear, in severe cases, these first means will be replaced by provisional intrabuccal prosthetic apparatus.

The slightest portion of the soft parts covering the superior maxillæ that have been lacerated by bullets or shell fragments should be preserved. Median or lateral losses of substance on the roof of the hard palate are generally repaired by prosthetic apparatus.

Wounds of the Inferior Maxilla. — The inferior maxilla, a compact bone, presents lesions comparable to those of the diaphysis. The borders are gouged, furrowed by oblique fissures, with cuneiform direction of the grooves. Perforations are complicated by radiated X-shaped fissures, like perforations of the diaphysis. The line of fracture is rarely simple, and represented by one or two vertical or oblique lines. The teeth are fractured, pushed or propelled out of their alveolar cavities. Splinters are relatively not very extensive; they are maintained in position by the thick periosteum, the mucous membrane, and the attachments of the muscles, they may, however, be displaced.

Nearly always there is no displacement of the large fragments. Sometimes they tilt inwards, exceptionally outwards; most frequently forwards and downwards through the action of the genio-hyo-glossus and genio-hyoid muscles. In some cases there is overlapping.

Fragments of large projectiles occasion contusions, simple fractures after tangential contact, or else partial or total abrasions of the body of the maxilla. When the lesion involves the body of the bone, the result is a large buccal hiatus, open in front, invaded by the tongue, which hangs

out in front of the neck. With less severe injuries and separation of the genio-hyo-glossi, the tongue rather tends to drop back into the larynx.

Very different from the injuries of the superior maxilla, which in the majority of cases are benign, those of the inferior maxilla must always be looked upon as *grave*. Local infection is the rule; pus accumulates and remains in the buccal floor, and is continually being swallowed. Purulent general infection is very frequent. Osteitis or necrosis of fragments, both long and difficult to repair, at times osteomyelitis—such are the consequences of localized infection.

Treatment must fulfil three conditions: (1) It must secure *incessant disinfection of the mouth*; (2) *facilitate easy draining for septic fluids to the outside of the mouth*; (3) *obtain immobilization of the fragments*.

1. All we have said regarding disinfection of the mouth in reference to the superior maxilla is applicable to the inferior.

2. Inclining the head forward; in case of need, an incision made under the maxilla, insuring permanent intra- and extra-buccal drainage, realizes the second condition.

3. As for immobilization, it is attained either by fastening the teeth together by ligatures, or by maintaining the inferior maxilla against the superior by means of a chin bandage. By inserting between the dental arches a flat but thick piece of cork hollowed into a double groove, or a slab of guttapercha, thus leaving a free space between the maxillæ, we facilitate buccal disinfection, and at the same time maintain coaptation of the fragments. Direct suturing has its advocates, but it should mainly be used in simple fractures.

We must respect splinters that have not been moved, even when they are only very slightly adherent, in order to avoid consecutive deviations towards the buccal axis. Fragments that have been pushed forward, like a free tooth, must be removed.

Hæmorrhage, a quite frequent complication, is arrested at first by compression, then by ligation. As to foreign bodies, which usually cause a great deal of irritation, they must be removed at an early period.

Subsequently loss of substance is filled up by prosthesis, and deviations are corrected by apparatus, which make good in the necessary places the damage that the maxilla has suffered (*Preterre*).

Wounds of the Tongue and the Buccal Floor.—Bullets striking the tongue produce furrows, setons, cul-de-sac wounds, or total perforations. They generally bring with them splinters or teeth that have been detached from the maxilla, especially from the inferior maxilla.

These wounds are sometimes complicated by abundant hæmorrhage, and, if they frequently end without septic accidents, yet on other occasions, though far more rarely nowadays with the present small bullets, they give rise to abscesses of the buccal floor, to septicæmia caused by the patient swallowing the intrabuccal fluids, and finally to glossitis.

The most common treatment required by wounds of the tongue is, in case of severe hæmorrhage, obturation of the buccal wound by tamponade or suturing; uninterrupted detersion of the mouth, relief by incisions of all constriction in the wound, and search for foreign bodies which may be lodged in the tongue, if we find there is glossitis, which causes so much trouble in deglutition and respiration; also median or lateral incision of the buccal floor, which should include the whole mylo-hyoid band, in order to give issue to the fluids of the cellular sublingual tissue; also angular sterno-mastoid incision to open up the peripharyngeal collections.

Wounds of the lips and cheeks present no special particularities. Strips of flesh from the lips, even when very much contused, must be carefully preserved. Lesions of Stenon's duct are exceptional.

CHAPTER XIV

WOUNDS OF THE NECK

THE proportion of lesions of the neck is 1 to 3 per cent. of all the wounds treated, but the number would increase by 3 per cent. if we take into account all the immediate deaths that occur.

Two-thirds of these wounds are simple (Ferraton).

Those of the larynx and the œsophagus would be exceptional. Wounds of the neck often involve the cervical part of the vertebral column.

The track may be *antero-posterior*, *transverse* or *vertical*, direct or oblique.

The antero-posterior pretty frequently involves isolated organs; on the other hand, it often includes injury to the vertebral column; deep transverse tracks lead to more complex lesions. Wounds of the supra-hyoid and of the upper supra-clavicular regions are not so serious as those of the parotido-carotid and sub-hyoid regions. Wounds of the posterior regions of the neck are the least serious.

Wounds of the Nape of the Neck.—Let us simply call attention, without dwelling upon the subject, to more or less deep cuts or stabs given by cold steel on the nape of the neck. Bullets hollow out in this region either short or extensive tracks, with or without hæmatomata; shell fragments leave large, deep furrows, extending as far as the vertebral column.

These wounds are benign ; there is nothing particular in their treatment.

Wounds of the Antero - Lateral Regions — Soft Parts.—They comprise the supra- and sub-hyoid regions, that contain the laryngo-tracheal and pharyngo-œsophageal passages ; they also comprise the carotido-parotid regions abounding in large vessels and nerves.

The lesions of the sterno-mastoid, and of the other cervical muscles, consist of notches, perforations, and sections.

Wounds of the carotid or of the subclavian arteries are *contusions*, *lateral wounds*, *perforations* ; only fragments from large projectiles give rise to *sections*.

Hæmorrhage from the carotids is nearly always fatal. Nevertheless, arterial hæmatomata are sometimes seen. These hæmatomata, which take on a very rapid development, cause grave compression accidents, implicating the vessels, the nerves, the laryngo-tracheal and œsophageal passages, denoted by circulatory troubles in the head and brain, and nervous and respiratory troubles, dyspnœa, suffocation. They diffuse as far as the axilla and the mediastinum. The blood from these arteries penetrates sometimes into the larynx or the trachea, giving rise to bloody expectoration, causing grave or fatal hæmoptysis, asphyxia ; if the blood flows into the pharyngo-œsophageal canal, it is either swallowed or vomited.

Open lesions of big veins (*lateral wounds* and *perforations*) give rise, according to the diameter of the external wounds, to very abundant hæmorrhage or to venous hæmatomata.

Wounds of very big veins, such as the internal jugular, the sub-clavian, the venous brachio-cephalic trunk, are as grave as those of the accompanying arteries. Their size, the absence of valves, and the resulting emptiness of the cranial sinuses, render hæmorrhage from the internal jugular particularly formidable.

Lesions of the *nervæ* of the neck present no particular anatomo-pathological characteristics.

A bullet does not *fracture* the larynx or the trachea in the ordinary meaning of the word; it causes *contusions*, *indentations*, clean *perforations*.

These indentations and perforations bleed moderately, but they remain widely open; the result is that in cases of simultaneous lesions of the neighbouring large vessels the blood runs freely into the respiratory passages.

The thyroid is *indented* or *perforated*. A bulky fragment of a large projectile may partially abrade it, as it also might abrade the larynx or the trachea.

The *pharynx* and *œsophagus* are *contused* or *perforated*. In the case of the *œsophagus* it is rather difficult to recognize the lesion at first sight if the tube has not been artificially dilated.

Diagnosis.—In the narrow wounds produced by bullets the diagnosis of pharyngo-œsophageal lesions becomes very difficult; it remains uncertain in the large majority of cases. The escape of food and saliva, a pathognomonic sign, is wanting. Dysphagia, pain or difficulty in deglutition, will be about the only signs, sometimes with vomiting of blood, which is rare. In case of doubt, one should act as if the pharyngo-œsophageal lesion existed, and be ready to interfere at the slightest threatening of peri-œsophageal infection.

Wounds of the laryngo-tracheal passage by projectiles hardly ever are recognized by the noisy entrance or escape of air through the cervical wound, a pathognomonic sign. The diagnosis may, perhaps, be rendered less difficult by the rapid apparition of an extensive and deep emphysema. Cough coming on in fits, asphyxiant dyspnœa, bloody expectoration, aphonia, which occurs in subglottic wounds, finally, the *relations of the track with the respiratory passages* will furnish the rudiments of the diagnosis. The

most characteristic symptom of penetrating wounds of the laryngo-tracheal passage is dyspnœa, with threatening asphyxia.

In cases of simultaneous lesion of the respiratory and œsophageal passages, ingested fluid will pass into the trachea, and may be expelled by cough or through the cervical wound; but we must not rely on this symptom, for it is rather by the whole of the preceding signs that these wounds are recognized.

To establish the origin of *alarming hæmorrhage* is usually very difficult, because of the number and the close relationship of the large jugulo-carotid vessels.

The disappearance of temporal or radial peripheral pulse is not always an indication of a carotid or subclavian section (collateral circulation, compression by a hæmatoma).

Nearly always the diagnosis of nervous lesions will not be made until at a period more or less remote from the date of the traumatism (Ferraton). At first their symptomatology is masked by that of the neighbouring lesions, the extreme gravity of which occupies all our whole attention.

Wounds of the thyroid body are diagnosed by the relations of the external lesions, by hæmorrhage (which generally is moderately abundant), and by the appearance of a hæmatoma.

Prognosis.—The evolution of the injuries of the neck by projectiles is frequently aseptic when the soft tissues are the only ones involved. On the other hand, lesion of the laryngo-tracheal and pharyngo-œsophageal passages, the presence of foreign bodies, wide-spreading hæmatomata, promote or favour the development of circumscribed or diffuse abscesses, in different strata of the region. These abscesses, sometimes enormous, are of a decidedly inflammatory type, sometimes ultraseptic, ligneous, with emphysematous gangrene.

Limited or extensive emphysema is an immediate com-

plication of these wounds, likewise asphyxia by laryngo-tracheal compression due to effusion of blood or to extensive emphysema; broncho-pneumonia is a later complication.

The prognosis is favourable in simple wounds. It is very bad in those that involve the large vessels. It is grave in lesions of the larynx, the trachea, the laryngo-tracheal passage. The narrow wounds of the laryngo-tracheal passage are perhaps more grave than the large lesions.

Instant or very rapid death occurs frequently; when delayed, the fatal ending is due to hæmorrhage or to the complications stated above, especially to broncho-pneumonia.

During the Hispano-American War, out of 119 wounded in the neck, 24 died on the battlefield, and 22 subsequently.

Treatment.—The immediate and prolonged treatment of simple wounds presents no special indications; however, it is well to mention, with Professor Ferraton, that the dressing must obtain support from the forehead or in the axilla, to avoid all chance of displacement. Immobilization of the head is absolutely necessary.

To combat severe hæmorrhages, digital compression should be applied to the wound, followed by mechanical compression localized on the wound, exerted either through the integument or on the vessel itself, after it has been relieved from all constriction. By giving solid support from the head and from the axilla on the same side, and by making the dressing very thick, we can exert strong lateral compression, which at first sight would seem to be hardly bearable. We have noticed this again and again. Ferraton advises covering the dressing with a wooden or zinc splint kept in place by the spica bandage of the neck.

Ligature of both ends is the ideal treatment, but in its application it necessitates coolness and all the ability of a skilful surgeon.

Wounds of the veins require the same treatment as those of the arteries.

Tracheotomy should be performed on men wounded in the larynx and trachea. This must be done at once; it must be expeditious and preventive—that is to say, it should be utilized in cases in which asphyxia is not threatening, and on the first signs of emphysema.

When a pharyngo-œsophageal wound is suspected, food must no longer be introduced into the mouth; we must have recourse to watery or nutrient enemata, or to subcutaneous injections of normal saline; thirst is to be treated by frequent rinsing of the mouth.

Abscesses should be opened, the line of incision for ligatures being followed, this being along the anterior border of the sterno-mastoid; rarely along the posterior border or in the supra-clavicular space.

CHAPTER XV

WOUNDS OF THE CHEST

IN the ambulances lesions of the chest represent an average proportion of one in ten or thirteen wounded, but a third of these wounded have already succumbed on the battlefield, and count among the killed; at the rear the proportion is from 6 to 8 per cent. (Laurent). Sometimes the entire lesion is in the thorax; sometimes one of the adjoining segments of the upper extremity is also implicated.

Injuries of the chest are divided into—(1) *Non-penetrating wounds*, and (2) *penetrating wounds*.

Non-Penetrating Wounds.

They include wounds of the *soft parts*, and wounds of the *bones and cartilages*.

Among the wounds of the soft tissues which resemble those of all other parts, we will only mention the arterial lesions of the very vascular scapulo-pectoral region.

The bony injuries present the same type as the lesions of long bones (clavicle, ribs), of spongy bones (sternum), of flat bones (scapula).

Clavicle.—On the body of the clavicle, which is frequently injured, we see *contusions*, *simple* or with *extensive fissures*; *fractures by contact*, either transverse or oblique; *grooves* and *perforations*, either of the simple or the comminuted type. Comminuted perforations, the most frequent,

have splinters, generally short, like those seen in very compact bones. They are nearly always adherent.

The extremities of this bone present lesions of the epiphysis. The relations of the larger vessels and nerves in the base of the neck with the inner end of the clavicle, and those of the subclavian and axillary vessels and nerves with the centre of the bone, render wounds of this bone very dangerous. The wounded who present these complications nearly always succumb on the battlefield.

Immobilization is absolutely necessary. It is obtained by an arm-sling, more securely by bandages applied in the manner advocated by Velpeau or Desault. No exploration whatever. Instances are reported of simultaneous fractures of both clavicles or of the clavicles and sternum.

Scapula.—The scapula is frequently injured. Its lesions belong to the class of injuries of the flat bones without diploë (the body), or with diploë (the spines, the borders). They consist of *perforations*, generally clean, on the body of the bone, or *notches* on its borders.

It is important to consider the direction taken by the projectile. When this is *antero-posterior*, the free splinters are superficial, of easy access, and extrathoracic. When *postero-anterior*, the free splinters are deeply situated under the body of the bone, and of difficult access. When *transverse*, which is the most usual, the lesion is less regular and more complex. The bullet, even when it simply grazes the bone, produces a fracture with numerous fragments, which are either maintained in place or depressed, with radiating fissures or a *slanting perforation* (Delorme). These fractures are of the greatest gravity.

Lesions of the acromion and the spine show some analogy to those of the skull; they are notches, extensive grooves, clean perforations, with or without fissures, and free splinters near the bony aperture of exit. As for the coracoid process, it may be notched, perforated, or separated.

Lesions of the scapula may give rise to considerable hæmorrhagic, œdematous, or inflammatory swelling of the surrounding parts.

TREATMENT.—No exploration, no immediate interference for the removal of free splinters. Immobilization of the limb by means of an arm-sling or bandages.

COMPLICATIONS.—Hæmorrhage, often severe, from one of the three scapular arteries, renders compression, or better still, ligature, necessary. The effusion of blood caused by a wound of the vessels that surround the scapula is sometimes very abundant, and may find its way even down to the sacrum.

Suppuration, in infected wounds, is to be feared by reason of its depth, its diffusion under the scapula, and because of possible thoracic infection. Formerly it contributed towards raising the death ratio to 12·3 per cent. of these cases. Free escape should be given to the pus through large periscapular incisions.

Let us also mention the presence of subscapular foreign bodies, the removal of which requires similar incisions. Foreign bodies are revealed by radiography, sometimes by subscapular friction sounds.

Sternum.—Wounds of the sternum are rare; they are perforations with linear divisions of the periosteum, sometimes erosions and furrows.

Ribs and Cartilages.—Unlike the other bones of the thoracic wall, the ribs are seldom affected singly, unless it be through tangential firing (contusions, grooves); whereas with bullets that penetrate we find *notches* with or without transverse or oblique fracture, *perforations* with radiating fissures and splinters, either free or pushed onwards, and corresponding to the last part of the thoracic wall through which the projectile has passed.

Penetrating Wounds.

They are frequent. They are seen in one-tenth of the wounded under treatment in hospitals. The most common are those with an *antero-posterior* track. The surgeon, by calling on his anatomical knowledge, can tell by the position of the wounds what are the parts that have been injured. *In the lower part of the chest, from the fifth rib downwards, the wound becomes thoraco-abdominal.*

Transverse tracks are often accompanied by lesions of the arm. These tracks should be designated as *postero-anterior*, *vertical* (cervico-thoracic).

Contour wounds no longer exist. The track followed by a non-deflected bullet is rectilinear. A deflected or pivoting bullet, a round shrapnel bullet, may make a sinuous and irregular track, but never the contour wound formerly considered classical.

Simple penetrating wounds, or wounds that implicate the pleura, are exceptional. The majority are penetrating with a lesion of the lungs or heart.

Wounds of the Lung.

Penetrating Wounds with Injury of the Lungs.—Being elastic and not very dense, the lungs usually present pretty simple lesions when injured by bullets fired at point-blank range, such as the following: *Fissures, furrows, cul-de-sac wounds*, or *total perforations*. The aperture of entry is circular, oval, like a slit, or narrow; that of exit is less regular. The canal is not lacerated, but is *slightly* suffused with blood; its walls adhere.

The dimensions of the apertures and of the track are the same as the diameter of the projectile (short range) or inferior to it; the apertures then each look like a small red spot (3 millimetres). Remote fissures are seldom met with.

A healthy lung may present a large gap at the aperture of exit of the bullet, but it does not burst. There is no explosive effect.

Shrapnel bullets form somewhat larger tracks. The aperture of entry is rounded, that of exit more extensive and irregular (Laurent). The sanguineous trail that indicates the bullet track is undiscoverable at the end of a week (Laurent).

Diagnosis.—Shock varies, sometimes slight, “so much so that the wounded man can continue to fight or go on foot to the ambulance, even if it is at a considerable distance” (Laurent); sometimes marked: “The grave lesion brings down the wounded man and leaves him almost bloodless for several hours” (Laurent).

Most of the wounded men say they feel a *pain* resembling the stroke of a whip. This pain may be very violent.

Dyspnœa is aggravated by fractures of the ribs. *Escape of blood through the external wound*, which is rather rare, has no particular signification, unless it is concomitant with hæmoptysis.

Hæmoptysis is a surer sign. Slight, average, or excessive, it varies between the spitting out of a few sputa, either immediately or during two or three days, and the expectoration of a litre of blood or more. In both cases it is *characteristic*. Laurent has found it in 75 per cent. of the wounded, others have noticed it in one-third of the cases. *Issue of air from the wound*, *traumatopnœa*, *emphysema*, are not frequent. The same may be said of *pneumothorax*. *Hæmothorax* is an excellent sign. *Contraction* of the abdominal walls has been noticed. *Spontaneous immobilization of the chest* occurs habitually. Lastly, let us recall one of the most favourable signs—*the connection of the track with the lung*.

The wounded zone should be specified so far as possible:

(1) The *peripheral zone*, the small vessels and the bronchioles being the only parts affected. (2) The *middle zone*

with vessels and bronchi of medium size. (3) The *central zone*, region of the hilum and of the larger bronchi.

Wounds of the middle zone present the plainest symptoms, and the ones most usually observed ; those of the hilum are the worst.

Complications.—*Hæmothorax* is the most serious primary complication in wounds of the chest. It is often concomitant with partial pneumothorax. Variable as to the rapidity of its course and the abundance of its contents, it may entail the death of the wounded man, or else throw him into the gravest state of acute anæmia, or finally it may be found compatible with life.

It is reabsorbed in the majority of cases treated by the surgeon. The wound would be exposed to infection if interfered with under precarious conditions. *Pneumonia* is exceptional.

Pleurisy is a frequent consecutive complication. It is adhesive, serous, or purulent. A large thoracic wound, infection through fragments of clothing, large hæmothorax, favour its appearance. It accounts for the fever of the wounded man. Its treatment, which here offers nothing special, is one of the most active amongst those for wounds of the chest by projectiles.

Hernia of the lung is very rare ; *extensive emphysema* is exceptional ; *foreign bodies* (splinters, bullets, fragments of clothing) are pretty frequently noticed. Metallic foreign bodies have a tendency to find their way into the pleural cul-de-sac.

Treatment.—It is simple, and carries out the following indications :

(1) *Rest for the wounded man.* (2) *Application of dressings, with occlusion of the wounds.* (3) *Immobilization of the thorax.* (4) *Treatment of complications.* No extensive surgical intervention is to be undertaken.

1. At the shelters for the wounded ; at the relief and

first aid station; at the ambulance: *Rest* in a supine or sitting position.

The wounded must be raised with the greatest care, to avoid syncope, cough, pain, detachment of clots.

When they present lesions of the central zone, the wounded must not be sent back to the rear. Their transport should be effected as much as possible on stretchers, and should be strictly limited to the distance necessary to take them to the *nearest* ambulance.

Transporting to a distance makes the prognosis much more serious. Against pain and dyspnœa, injection of morphine.

2. *Dressing*.—It must be *occlusive, without suture*. Occlusive to prevent the access of the external air, but not enough to hinder the exit of the intrathoracic air. Thus emphysema is prevented. We must be careful not to introduce drains into the wounds; their use gave rise to deplorable results during the Balkan War. We should abstain from suturing either direct or instrumental.

After touching the wound and its immediate vicinity with tincture of iodine (only once), the dressing is applied. *It must be very large*, covered with cotton-wool, and should include the whole thorax and even, according to the seat of the wound, the adjoining regions, the abdomen, the neck.

3. The dressing, firmly maintained by a body bandage, will secure *immobilization of the thorax*. Loosening of the dressing will be prevented by more bandages. This dressing is to be preferred to bands of sticking-plaster applied round the thorax over aseptic gauze.

4. It is chiefly in serious cases that the application of the above-mentioned methods of treatment should be very complete.

In cases presenting a grave general state, especially when it is connected with hæmothorax, we must make a point, according to the case, of administering *anodynes*, of

giving injections of morphine, making the patient keep, so far as possible, the semi-recumbent position, or at least a lateral one on the injured side. We must also have recourse to alcoholic *stimulants*, to cardiac tonics (ether, caffeine, camphorated oil), to injections of adrenalin, chloride of calcium, normal saline, to circular ligation of the limbs at their proximal end in order to secure venous stasis.

If asphyxia is threatening, we should aspirate, which must be repeated if necessary; but as a general rule it is best not to meddle with hæmothorax. It insures a salutary compression. Aspiration should not be carried out till after the first twenty-four or forty-eight hours.

Although we advocate great extensive interventions in those cases of very severe intra- or extra-thoracic hæmorrhage we see in civil practice, we have always been opposed to them in ambulance work. They would be neither opportune nor wise, for reasons we cannot here develop. *Even in extreme cases one must abstain from any big operation.*

Pleurisy, which, we repeat, is frequent, calls for *puncture* at first, then for the operation for *empyema*, so soon as the pus is revealed by the Pravaz syringe. This operation is one of the triumphs of thoracic surgery in these cases. When done early, it insures rapid recovery. No washing out is necessary; large dressings renewed at frequent intervals; no portions of rib resected (Laurent), for the tendency towards rapid recovery is here strongly marked.

In very extensive wounds, the result of shell splinters, hernia of the lung may necessitate, according to cases, reduction or ligation. Against *generalized emphysema* we should employ a large incision of the tissues as far as the muscular wall, or overlapping circular incisions.

The extraction of the foreign bodies will be done subsequently through a sloping incision.

In *thoraco-abdominal wounds* the abdominal lesion dominates, and *abstention* is our line of conduct.

Prognosis.—Thus treated, and without being transported, men wounded in the chest recover rapidly and completely when primarily the wound has not been of very great severity. A very large number of thoracic bullet wounds surprise us by their extreme benignity. This is because the pulmonary wound is narrow, not complicated by the presence of foreign bodies (make certain by inspection of the clothes that there is no loss of substance from them), and without notable hæmorrhage, the lung wound being peripheral.

WOUNDS OF THE HEART.

They are never, so to speak, met with in the ambulances (Laurent); the same may be said of wounds of the large vessels. The great interest with which the former are regarded in daily practice, by reason of the brilliant operations they give rise to, ceases to exist in war surgery. In our sanitary formations abstention must be the rule, because of the risks in surgical interference, the dangers of infection, etc.

In the very rarest contingencies only an exception to this rule may exist, therefore we will simply pause an instant to state that the heart, when wounded by bullets fired from a short range, has sustained explosive effects; when the bullets are from other distances, it is eroded or perforated.

Expectation is the line of conduct to follow: it includes absolutely perfect rest, absence of all excitement, the use of morphine, and immobilization of the chest.

CHAPTER XVI

WOUNDS OF THE ABDOMEN

COUNTING deaths on the battlefield, the percentage of wounds of the abdomen, according to Ferraton, is 13 or 14. That of the wounded received in the ambulances fluctuates between 7 and 10; a very small number of these cases are transported to the base hospitals.

The proportion of penetrating wounds is 50 per cent. These statistics, which are partly of ancient date, require revising and completing.

The claims of diagnosis, and also those of categorical statistics, have already made an exact knowledge of the abdominal regions absolutely necessary to the surgeon; on the other hand, the relations the external orifices of the wounds bear to these regions constitute indications of the highest value, in spite of the displacements which, through respiratory movements or change in the position of the body, certain movable organs may undergo.

In planning out the abdomen, we divide it into three stories one above the other: the first or *superior* is situated between the diaphragm, the dome of which corresponds with a horizontal line passing through the fifth rib, and another line, also horizontal, which just touches the thoracic brim.

The second or *middle* is contained between this last-mentioned line and the horizontal plane between the two anterior superior iliac spines.

The third or *inferior* is situated below the iliac plane just mentioned, thus corresponding to the pelvis.

The upper space is *thoraco-abdominal*.

Two vertical lines starting from the centre of Poupart's ligament divide this space into three secondary zones: the *right hypochondrium*, the *epigastric*, in the centre, the *left hypochondrium*; these lines also divide the *middle abdominal space* into two lateral regions, the *right* and *left lumbar*, with the *umbilical* in the centre and finally divide the *inferior* story into *right* and *left iliac* and *hypogastric* in the centre. The following table shows the organs contained in each of these nine regions:

RIGHT HYPOCHON- DRIUM.	EPIGASTRIC.	LEFT HYPOCHON- DRIUM.
Cul - de - sac of the pleura. Diaphragm. Liver, biliary ducts, portal and inferior cava veins.	Stomach. Pancreas. The great omentum (posterior cavity). Left lobe of the liver. Coeliac axis. Aorta. Vertebral column.	Thorax and pleura. Spleen. Left kidney.
RIGHT LUMBAR.	UMBILICAL.	LEFT LUMBAR.
Ascending colon, he- patic flexure, hid- den under the liver. Duodenum. Right lumbar fossa.	Stomach, when dis- tended. Great omentum. Mesentery. Small intestines. Transverse colon. Aorta. Inferior vena cava. Vertebral column.	Descending colon.
RIGHT ILIAC.	HYPOGASTRIC.	SOFT ILIAC.
Cæcum. Iliac vessels. Anterior crural nerve. Pelvis.	Cavity of Retzius. Bladder, when full. Rectum. Aorta. Inferior vena cava. Vertebral column. Sacrum.	Sigmoid flexure. Iliac vessels. Anterior crural nerve. Pelvis.

Antero-posterior tracks, by far the most common, often affect but one region; *transverse* cracks go through several

regions, either horizontally or obliquely. Vertical tracks are rare.

Cold Steel Wounds.—These are deep, though they do not always wound the intestines (bayonet, lance), and superficial (cutting weapons).

Non-Penetrating Wounds.

Contusions, *cul-de-sac wounds*, *parietal perforations*, may be seen on the abdominal wall. In tangential firing the furrow or the seton made by the bullet is sometimes very extensive. Fragments of large projectiles make on the abdomen furrows or setons, especially very long furrows.

Penetrating Wounds.

Simple penetrating wounds are exceptional. A bullet that goes through the wall produces always, so to speak, a penetrating wound with a visceral lesion.

Lesions of the Intestine.—In the small intestine, which is the more often wounded, and whose lesions may be regarded as types of wounds of hollow organs, we see *contusions*, *tearing*, or *perforations*. Perforations are very common; they are multiple in the intestine, frequently four in number, but as many as thirty have been seen. They are generally most numerous from transverse firing. The lesions are less from bullets which have but a small velocity; they increase in size with average velocity and more especially with great velocity; this is an important fact. Their size is in proportion to the calibre of the bullets, therefore they are larger when caused by shrapnel bullets or shell fragments than by ordinary modern bullets. They increase in size with flattened bullets, but they become much smaller with pointed bullets, whose wound resembles a puncture.

The orifices of the perforations are circular or oval, sometimes almost like a mere slit, punctiform, and more often

with loss of substance. The aperture of entry looks as if it had been punched out, and gapes; the aperture of exit is everted, with the mucous membrane bulging, and is often larger than the aperture of entry. Sometimes the two orifices are quite near to one another, and only separated by a little bridge; more often, however, they are wide apart.

1. At a *greater* distance than 400 metres, the *present bullets of small calibre* generally leave *very small perforations*, which might almost be called simple punctures; they have a great tendency to close up spontaneously (Ferraton). Through these orifices, when they are larger than simple punctures, the mucous membrane is pushed out like a hernia; and it prevents to a certain extent the egress of solid or liquid intestinal material, but not that of gas. The contraction of the peripheral muscular fibres narrows the openings; when the contraction ceases, the localized inertia of the intestine prevents the escape of fluids.

2. When the bullet has been fired from a *less distance* than 400 metres, when it has struck obliquely, and has undergone a deviation before reaching the intestine, when the projectile is a shrapnel bullet and *a fortiori* a shell fragment, the intestinal orifices are *like the cutaneous orifices*, the latter showing the extent *de visu* of the former, but *larger* and less likely to be closed by the mucous membrane. The stercoraceous effusion is then more abundant, more continuous than in the first case, in which it may be very small, especially if the wounded man was fasting.

At very short distances we see explosive effects: bursting of the intestine, large gaping wounds, especially if the bowel was full at the time of the wounding; nevertheless, severe disturbance, owing to pointed bullets, is less common than formerly. They would be frequent with bullets having a blunt extremity (Austrian and Russian). Contused *sections* are very exceptional (shell fragments).

These typical lesions of the small intestine are also seen

in the large intestine. The large bowel is more vulnerable because it is fixed ; but its perforations are less grave by reason of the solid nature of its contents and the absence of mobility, which prevents dissemination of contaminating products.

The same lesions are also seen in the stomach, the rectum, the bladder, and the gall-bladder.

In the **stomach**, whose walls are thicker than those of the small intestine, perforations are generally narrower, and with more tendency to close spontaneously. The vascularity of the organ makes the patient liable to intraperitoneal hæmorrhage or to hæmatemesis.

The perforations are generally double, and involve at the same time the anterior and the posterior wall (effusion easily taking place into the large peritoneal cavity or into the posterior cavity of the omenta). Like the intestinal walls, the wall of the stomach may be contused or grazed.

The liver presents the typical lesions of abdominal parenchymatous viscera. They consist of contusions (exceptional with rifle bullets, more frequent with shrapnel bullets), *furrows* and *grooves* scooped out on the surface, *cul-de-sac wounds*, or *total perforations*.

The orifices and the tracks made by the bullets are generally narrow, rounded, not gaping, but prolonged by fissures whose *depth*, *extent*, and *number* are connected with the velocity of the bullet. These fissures are all the more numerous and deep the greater in general the velocity—that is to say, the nearer the firing.

From a short distance we see *explosive effects*, with numerous subdivisions, both locally and at a distance, the apertures of exit much enlarged, gaping, and bleeding. The liver being a very vascular organ, it bleeds copiously.

In the **spleen**, which is just as vascular, the orifices and tracks are in general larger than in the liver, and more complicated, with extensive fissures.

The **pancreas**, whose traumatisms may be complicated by lesions of the stomach, the duodenum, the liver, etc., presents wounds analogous to those of the liver, though less severe by reason of the greater solidity of the pancreas.

To sum up, the principal cause of the gravity of abdominal penetrating wounds by projectiles is the frequency and copiousness of the immediate effusion, the vast *effusion of blood* furnished by the parenchymatous organs and the large vessels, but also, in addition, by vessels of the second and third class, from which the hæmorrhage, though not so sudden, is none the less grave by reason of its persistence; and, again, there are the pourings out of *food and secretions*, both *irritating* and *septic*, giving rise to the very gravest local or general reaction, to peritonitis.

Poured out in large quantities, the blood, aided by gravity, invades the lower parts of the body, the flanks, the exterior of the colons, or more often the iliac fossæ and the true pelvis. The effusion on the right side penetrates directly into the right iliac fossa; on the left side it descends into the left iliac fossa and into the true pelvis.

When less abundant, the effusion, instead of filling the peritoneum, may accumulate as a collection of pockets in the neighbourhood of the lesion in the wounded viscus.

The mixture of the blood with the septic products of the hollow organs gives rise rapidly either to the formation of adhesions, or to septic or purulent peritoneal effusions, sometimes circumscribed in the vicinity of the visceral lesion, sometimes multiple, sometimes generalized.

Peritonitis is the great danger in these wounds, and the higher the lesion the greater the risk of this complication. A well-known fact is that the power of absorption of the peritoneum is specially marked in the superior peritoneum above the transverse colon, and that it is reduced to a minimum at the level of the inferior peritoneum and in the true pelvis.

Diagnosis.—Although the symptoms of the traumatism of the abdomen by the weapons of warfare are in a great degree like those we observe in similar lesions of ordinary practice, it may be as well to call to mind their chief differential characteristics.

Shock, pain (rarely acute), dyspnœa, nausea, vomiting, are all often absent; a small *pulse* is unreliable at first; *disappearance of the liver dulness* is a valuable symptom, but it is very variable, as also is *dulness in the iliac fossa*.

Escape of blood through the anus is a late symptom, and *subcutaneous emphysema* is rare. Primary diagnosis is based, in short, on *rigidity of the abdominal walls*, a *wooden feeling of the abdomen*, *absence of abdominal respiration*, finally, by the *relations of the external perforating wounds to the regions of the abdomen*. We can assert that these lesions are always perforating under normal conditions of fire; therefore, if we cannot feel the projectile *in the abdominal wall*, we can practically say that a track exists in the abdomen formed by the projectile, and we therefore diagnose a *perforating wound*.

Hæmorrhage is revealed by signs of *acute anæmia* and by the discovery of *rapid effusion into the iliac fossæ*.

Peritoneal reaction, nearly always fatal after *penetrating wounds*, shows itself especially by *peritoneal facies*, *dissociation of the pulse and temperature*, *inguinal or rectal tenderness*, *vesical tenesmus*.

Hæmatemesis would indicate a lesion of the stomach, but it is a rare sign; *radiating pains in the right or left shoulder* are the only indirect signs to remember amongst those that are given for the diagnosis of lesions of the spleen and of the liver, for *jaundice* and *escape of bile* through a narrow wound are uncommon, and *escape of splenic substance through the wound* or *hernia of the viscus* are only seen in large wounds produced by shell splinters.

To sum up, a *localized diagnosis*, often very uncertain,

can only be guaranteed by proving the relations of the track to the different organs of the abdomen.

Course of the Case.—Aseptic evolution of *penetrating wounds of the abdomen*, even when intestinal lesions are present, has become less exceptional since the adoption of bullets having a small calibre and a pointed extremity, and cases with *limited septic evolution* and circumscribed peritonitis have also become more frequent. Peritoneal reaction, which has ended in an abscess, then remains more or less localized all around the visceral perforations; it is confined to one of the abdominal divisions or to one side of the abdomen, above or below the transverse mesocolon, to the right or to the left of the mesentery. Unfortunately, far too frequent, almost habitual, is the *diffuse*, generalized, suppurative, or ultra-septic *peritonitis*, in the form of peritoneal septicæmia and super-acute intoxication, with hypothermia, dissociation of the pulse and the temperature, thready pulse, inert belly, tympanites, abdominal facies, vomiting—first bilious, then fecaloid—scanty urine, general depression, but without loss of intelligence. All these symptoms demonstrate the gravity of this complication.

Foreign bodies derived from the clothing pushed forwards by deflected bullets, shrapnel bullets, or fragments of large projectiles, contribute on their side to peritoneal infection. Metallic foreign bodies in themselves are a very small complication, and their presence would at first have no influence on the treatment. *We must avoid all attempts at immediate removal.* We will only mention, in order that it be remembered, their escape after ulceration of the hollow viscera.

Prognosis.—*Immediate* death is less frequently the sequel of penetrating wounds of the abdomen than that of lesions of the skull or of the thorax, for it has been noted only in an oscillating proportion of one-half and one-fifth of the fatal

cases on the battlefield (shock, hæmorrhage); but this is but a deceptive point of view in reference to their gravity. Another *fifth* of these patients die *rapidly* in a few hours in the fixed or movable ambulances, and definite cure, as yet but badly shown by statistics with regard to the traumatism caused by the present projectiles, is probably not seen in a *half* of the *remainder*. However, one fact stands out clearly—that the excessive mortality (92 in 100, Crimea; 80 to 90 per cent., War of Secession; 50 to 70 per cent., Russo-Japanese War; 40 to 50 per cent., South Africa) diminishes as the calibre of the bullets become smaller and as treatment is better understood.

But this is not enough. These traumatisms are still too grave; therefore *wounds of the abdomen are those that should derive the greatest benefit from treatment in this war*. The results obtained, and the nature of the traumatisms, which is at present less formidable (pointed bullets), will help the surgeon to attain this object.

The *relatively benign nature* of a penetrating wound of the abdomen by a bullet is largely connected with the *diameter and the active force* of the bullet—that is to say, with the size of the intestinal wounds. The greater the range and the smaller the diameter of the projectile, the more the perforations are reduced in size. The *extent of the intestinal wounds is related to that of the external wounds*, which last serve as indications to us.

Wounds with *large orifices* made by deflected bullets, by bullets that have turned over in their course, by shrapnel bullets, by large shell fragments, are always *the most severe*, and at a range of less than 400 metres it is to be feared that the S and D bullets present the same gravity.

The lesions being equal, the *prognosis of wounds of the small intestine is the most grave* (immediate and abundant ster-coraceous suffusion). This prognosis becomes less serious with wounds of the stomach, and still less with those of the

large intestine, with the exception of the transverse colon, and, finally, still less with lesions of the rectum. Wounds of parenchymatous organs are less grave than those of hollow organs, and in order of their gravity we may mention the liver, the spleen, and finally the kidneys; and here again the question of active force and length of range comes into play. At reduced distances the tracks are wider, more gaping, more fissured, more likely to furnish a hæmorrhage which is formidable, on account of its abundance and its persistence.

Absolute immobility is an important factor in making the prognosis less unfavourable. It is one of the best. In the Transvaal, at Spion Kop, all the wounded, being in a mountainous country, and having necessarily to be transported over very rough ground, succumbed; at Jacobsthal a great many men who were not moved recovered. We have seen quite a series of wounded cured by expectation, the soldiers having been obliged to remain on the field of battle for several days without being able to move from one spot, with nothing to drink or to eat.

Treatment.—The treatment of penetrating wounds of the abdomen during a campaign has passed through three different phases—an old one, the expectant; an active one, extensive and early laparotomy; a third, the one of the present period, expectant, brought forward at first as a theory (Delorme, Chavasse, Haga, etc.), then confirmed by experience acquired in warfare. May the present war bring to light a fourth phase, in which treatment, more unvarying, more susceptible of generalization, and formations better adapted to circumstances and to the great variety of the lesions, will contribute to lower a mortality that is still excessive.

With regard to the treatment of perforating wounds, we will reproduce almost in full what we have already said in our "Advice to Surgeons."

Treatment of *wounds of the abdomen*, with lesion of the intestine, merits the undivided attention of surgeons, especially of the surgeons at the front. The treatment has been enriched by new methods, as yet not sufficiently known, the use of which will contribute to the lowering of the invariably dark prognosis of these wounds.

If we discuss the opportunities for *extensive laparotomy* in wounds of the abdomen and intestines in ordinary everyday practice, we find they are not at all the same in war surgery. *As a principle, immediate laparotomy* should be rejected. The most recent wars—Transvaal, Manchuria, Balkan—*have shown its harmfulness*.

In the Transvaal, although performed by eminent surgeons, under the best conditions for its success, it furnished many less cases of cure than did absolute abstention from operative interference, so much so that MacCormac was able to say: "A man wounded in the abdomen dies if operated upon; he lives if left alone."

During the Russo-Japanese War, on the Russian side, laparotomy was abandoned because of its want of success (95 per cent.); on the Japanese side it had to be forbidden. After the Italian-Turkish War (1912) it was condemned, and also in the French campaign in Morocco.

On the other hand, mortality consecutive to operative abstention fell from 87 per cent. during the War of Secession to 50 per cent. Its mortality oscillates between one-half and one-third.

Delay in the patient's arrival, difficulty of finding an aseptic centre, length of operation, the absolute necessity of treating simultaneously hundreds of wounded men all arriving at the same time, etc., are, together with the operative mortality, the principal and valid reasons for the rejection of extensive laparotomy, which should be considered as only an exceptional method.

From the point of view of treatment, we have divided these wounded into two groups—*those with narrow wounds*, those with *extensive wounds* (Delorme).*

1. *Narrow Wounds*.—As we have already seen, the German bullet, striking the abdomen *point-blank*, especially at long and medium ranges, makes in *the abdominal wall a narrow aperture of entry*, and does not carry with it infecting foreign bodies derived from the clothes. In the intestinal coils it only produces little orifices—very small perforations that have a tendency to close up spontaneously. Even in some cases it insinuates itself between the coils without perforating them. The immediate and valuable instinctive evacuation of both the intestine and the bladder, the fact of the wounded man remaining for hours on the same spot without experiencing the shock of transport, all these conditions prevent intraperitoneal suffusion, or, at any rate, circumscribe it, and promote recovery.

In this category of traumatisms the old treatment seems to suffice: absolute rest, no transporting to a distance, complete deprivation of food, and especially of drink, for several days—a regimen well borne, thanks to incessant rinsing of the mouth, rectal and intracellular injections of normal saline, finally to opium and Fowler's position.

2. *Extensive Wounds*.—When, on the other hand, the velocity of the projectile has been greater, the bullet has turned over in its course, or, in cases struck by shrapnel bullets, the circular or oval *aperture of entry in the skin* is bigger, the wounds also, as well as the intestinal lesions, are larger, and are less likely to become spontaneously obliterated; and complications resulting from shreds of clothing are frequent.

In these cases peritoneal infection is certain, but the

* Delorme, "On Wounds in War: Advice to Surgeons." Paper read at the Institute, August 10, 1914.

surgeon is by no means disarmed. To the treatment already indicated he can add, if possible, the continuous drop by drop rectal instillations of Murphy, especially the Murphy's quick incision and drainage, and copious washing out of the peritoneum with ether (Souligoux).

Murphy's incision, that Professor Ferraton has highly recommended in France, consists of a small button-hole cut made in the abdominal wall above the pubic arch. Through this incision, done at an early period under simple local anæsthesia after a rapid disinfection of the skin by iodine, the cavity of the pelvis is drained, and here, thanks to Fowler's position, septic fluids have a tendency to accumulate. This incision, therefore, represents a safety-valve; it prevents dangerous tension, which would promote re-absorption of septic products.

In seventeen patients suffering from wounds by projectiles, with perforation of the bowel, Harris, by the use of Murphy's incision, had seventeen successful cases.

Murphy's conception and technique are well suited to the conditions under which military medical service is carried out in the ambulances and hospitals. It opens up for surgeons a path they should resolutely follow. Here is no longer the complicated operation of classical laparotomy which a number of skilled surgeons could not repeat at the outside more than three or four times in a day, and even then by neglecting the other wounded men; a fatiguing operation, which increases shock, and is liable to destroy beneficial adhesions; an operation requiring a special armamentarium, minute aseptic precautions, and, after all, that ends by giving less cases of cure than abstention from operation. On the other hand, Murphy's incision is a very simple and rapid affair, within the capacity of every practitioner.

At Nancy, Professor Rohmer, evidently struck by the advice given in our communication, carried out Murphy's incision on several wounded men whom we saw. Some

were on the road to recovery. On the other hand, all the patients on whom Professor Weiss had performed laparotomy were dead. We also saw at Nancy spontaneous recovery from wounds of the abdomen in soldiers who had remained for several days lying on the battlefield, a hail of projectiles passing over them, and forced to fast all the time.

CHAPTER XVII

WOUNDS OF THE LUMBAR REGION AND OF THE KIDNEYS

THE lumbar region, occupied to a large extent by the kidneys, is limited on the inside by the vertebral column, below by the iliac crest, above by the twelfth rib. On the outside it is continuous with the abdominal wall on a level with the flank.

The frequency of traumatisms of the kidney has not been precisely determined. They are included, and not without reason, amongst wounds of the abdomen.

The *antero-posterior* course is the most frequent, then come the *postero-anterior* and the *transverse directions*. The descending colon and the spleen on the left side, the ascending colon and the liver on the right, and the pleura on each side, are often simultaneously injured.

Contusions are rare, and without much interest ; bleeding *excoriations*, *cul-de-sac wounds*, *through-and-through perforating wounds*, are the lesions generally seen. The extent of the perforations is in proportion to the velocity of the projectile. If the latter is slight or average, the track is narrow, and not, or very little, fissured ; it is wide and fissured with great velocity and with a short range. The perforations are clear or prolonged by multiple and starred fissures, especially near the aperture of exit. In explosive firing the

kidney may burst; the organ is fissured, deeply divided, separated into several bleeding fragments. The post-renal cellular tissue, less divided than the renal tissue, partly obliterates the posterior wound.

The *pelvis of the kidney* and the *ureter* are divided, perforated, and torn. Their lesions give rise to a flow of urine, which may become infiltrated in the perirenal tissue. On the other hand, wounds of the parenchyma by bullets do not produce any outflow of urine.

Wounds of the renal arteries and veins are followed by serious hæmorrhage, and with these lesions there is a risk of mortification of the kidney.

Outflow of urine from the posterior wound, a pathognomonic sign, is exceptional (parenchymatous lesions, narrowness of the wound, mixture of urine and blood). *Infiltration of urine*, which may form a lumbar urinary tumour, with a tendency, to diffusion towards the iliac fossa behind the peritoneum, is a characteristic of wounds of the pelvis of the kidney or of the ureter.

Hæmaturia, a characteristic symptom, lasting generally for several days, is a very valuable sign, but it has been observed in only one-thirty-fifth of the peripheral wounds. It would seem only to occur in central wounds.

Oliguria and anuria must also be mentioned.

The *relations of the external apertures with the region occupied by the kidney* furnish very valuable indications in the diagnosis. In width, the kidney occupies the middle third of the space included between the spinous apophyses and the lateral section of the body, and in height, the space that extends from a superior horizontal line passing across the eleventh rib, to an inferior one which would just touch the second or third lumbar vertebra.

The *immediate treatment* presents nothing in particular: wide dressings, absolute rest, nothing to drink. We must not meddle with renal effusions when they are aseptic.

For retention of urine, repeated catheterism, or a catheter tied in.

For profuse hæmorrhage, general hæmostatics; in case of insufficiency, *lumbar incision*, search for the kidney, direct compression by means of an aseptic pad, fixed by a partial suture to prevent its being pressed out, its action being assisted by an anterior compression of abdomen by a pad of cotton-wool.

We should not meddle with a fissured, even a divided kidney; the fragments which are nearly free are alone to be removed.

For the urinary outflow or a perinephritic abscess, *lumbar incision*. For pyonephrosis, *nephrotomy*.

The gravity of these wounds is especially due to both the kidney and the colon being injured; isolated wounds have generally a rather favourable prognosis. They usually heal in two or three weeks. With regard to complicated wounds, their mortality was formerly 50 per cent. (hæmorrhage, one-third of the deaths; infection complications, two-thirds), but the bad prognosis has diminished with the present bullets, although it is impossible to give precise information on this point.

CHAPTER XVIII

WOUNDS IN THE REGION OF THE PELVIS

Bladder, Rectum.

Wounds of the Soft Parts.—Ordinary characteristics and treatment are the same as those we see and employ in bullet lesions. The furrows and culs-de-sac produced by shell splinters are often large. The tracks made in the gluteal region expose the patient to grave hæmorrhage (gluteal and ischiatic vessels and their branches); temporary plugging, ligature after relieving constriction by free incisions. *The plugging should not be left in situ for long*, as so doing would render extremely grave putrid suppuration liable to occur, and, as we have lately seen in a German wounded man, hæmorrhagic suffusion of the pelvis, of the pelvic, iliac, and Retzian regions, with possible *diffuse aneurysms*.

Lesions of the Sciatic.—Nothing special in the treatment.

Lesions of the Pelvic Bones.—They are the same as lesions of flat or spongy bones: Oval or oblique perforations, either quite clean or with a few short splinters from the internal table, sometimes indentations or excoriations. Contusion is possible.

Pelvis.—*Penetration of the pelvis by bullets with SOLUTION OF CONTINUITY does not exist* (twenty bullets have passed through the pelvis without causing fracture—Delorme).

Immobilization of the pelvis, therefore, by a special apparatus is an inexplicable procedure.

Nothing particular with regard to treatment.

The *pelvic organs* are struck in their intra- or extra-peritoneal portions, or simultaneously in both. This division should be remembered.

The track is generally *antero-posterior*, and corresponds—(1) to the hypogastrium, to the floor of the perinæum, to the notches; (2) to the pelvis.

A *transverse* or *oblique* course is more uncommon.

Wounds of the Bladder.—*Contusions, excoriations, cul-de-sac wounds*, are exceptional; *total perforations* habitual. Orifices equal or inferior to the size of the bullet, generally narrow. The perforation of the serous coat is small, that of the muscular coat more extensive, and that of the mucous coat intermediate as regards dimensions. Hernia of the mucous membrane. Bursting is rare (explosive projectiles).

Tearing and puncture are possible by splinters.

Diagnosis.—The diagnosis is generally not difficult; it is anticipated by the *relations of the track with the bladder*, and would be confirmed by the *escape of urine through the wound* and by *hæmaturia*, either in spontaneous micturition or after the use of the catheter. These last signs in conjunction with the first are pathognomonic, but they are often absent.

Let us call attention to some *functional signs*: Radiating pain in the hypogastrium, in the perinæum, the loins, the genital organs; an *overwhelming desire* to pass water, to defæcate; retention of urine; finally, when there are complications, signs of peritonitis, infiltration of urine, urinary reabsorption.

Prognosis.—Some wounds heal easily, especially narrow wounds that are not complicated by a lesion of the rectum. Too often, however, we see peritonitis, urinary infiltration, the formation of simple or urinary abscesses, which develop in the cavity of Retzius and in the ischio-rectal fossa, and

which manifest their presence by a hard, œdematous, sometimes crepitant, hypogastric or iliac tumefaction, and by grave general symptoms (perivesical cellular tissue), or by a perineal abscess.

Immediate death is rare; rapid death in a few days is frequent (superacute peritonitis); delayed death takes place from the eighth to the twentieth day. It follows infiltration of urine or pelvic abscesses.

These wounds are rather often complicated by foreign bodies, shreds of clothing, pubic hairs, splinters, bullets, which may be the starting-point of stone in the bladder.

What is the proportion between deaths and recoveries? It is impossible to give it correctly. Bartels gives a mortality of from 45 to 50 per cent. The wounded in the Transvaal, where bullets of small calibre were employed, rarely recovered. According to Makins, the extraperitoneal wounds would hardly be less grave than the intraperitoneal. A concomitant rectal lesion is a very serious complication.

Treatment.—The *treatment* comprises two indications: Prevent the effusion of urine; contend against infection (peritonitis, pelvic or perinæal infiltration).

The first transport of the patient is to be carried out very cautiously, preferably in the *sitting* position; *nothing whatever should be given to drink*—this is capital; decubitus facilitates the outflow of urine; wide dressing often renewed—these are the first indications to fulfil. *The wounded man should expressly be treated on the spot where he fell.*

Catheterism, which was extolled by Larrey, is still the easiest and safest primary therapeutic measure; it is also the one most capable of generalization. We all know its incidental difficulties, its occasional inadequacy.

We must also make use of *catheterism with the instrument tied in* and changed every third day, of *intermittent catheterism* if the *tied-in catheter* is not tolerated. Deep drainage of the wound is advisable when the lesion is large.

The *button-hole median perineal incision*, which was recommended formerly when the catheter was badly tolerated, is replaced nowadays by *suprapubic cystotomy*—an excellent operation, but not capable of being generalized.

In cases of peritonitis, *Murphy's incision*. Experience will show up to what point it may be employed primarily.

Free laparotomy, with suture of the bladder, will be exceptional.

Wounds of the Rectum.—Isolated or concomitant with wounds of the bladder, lesions of the rectum present the same characteristics as wounds of the remainder of the intestine or of the bladder. They are either sub- or intra-peritoneal. We may consider it a case of the latter when the lesion lies at 5 or 6 centimetres from the anus; but generally the wound is both intra- and extra-peritoneal.

Escape of fecal matter from the aperture of exit is the pathognomonic sign of rectal wounds, but it is often absent on account of their narrowness. Escape of flatus and of blood through the anus are other characteristic signs, but they also may be absent.

We must abstain from injections if, when given through the wound, they return through the anus. Rectoscopic examination very rarely can be utilized. Rectal exploration with the finger sometimes enables us to discover the wound (tactile sensation and blood at the end of the finger). The length of the index is about that of the extraperitoneal portion of the rectum.

Simultaneous lesions of the bladder and rectum may be recognized by the signs of a wound of both of them.

To *prevent perirectal infection* is the principal indication of the *treatment*. *Dilatation of the sphincter* is a practice that is often employed, owing to its simplicity. Intrarectal dressing with vaseline and iodoform is preferable to the introduction of gauze. In the event of the latter being used, a large drainage-tube should be placed in the centre

of the dressing. Enemata are dangerous. Once a fæcal abscess has formed, or is threatening, *posterior rectotomy*.

Perirectal and presacral abscesses should be opened by a perinæal incision, followed or not by precoccygeal separation; iliac abscesses by the incision used for tying the external iliac; abscesses of the space of Retzius by a suprapubic incision.

No food at first, then alimentation consisting only of meat; opium must be given. These are the principal measures that help the treatment.

Wounds of the Prostate and of the Urethra.

In a perinæal or abdomino-perinæal track the prostate and the deep part of the urethra may be injured. The treatment of the former is included in that of the other wounded parts.

These wounds are recognized by the *urethrorrhagia* and by the *escape of urine through the wound*, sometimes, however, by direct examination.

Delicate catheterism, though dangerous, is a last resource. *De visu* we must judge of the feasibility of suturing the urethra. *Puncture of the bladder* may be necessary. With regard to retention of urine and urinary abscess, which may complicate the urethral lesion, they necessitate a button-hole perinæal incision.

Wounds of the Genital Organs.

Wounds of the genital organs are often concomitant with lesions of the thighs or of the pelvis.

They are not rare. We have seen a complete series of these cases in the hospitals of Nancy, and more particularly in those of Bordeaux.

Perforations of the *scrotum* give rise to a *hæmatic swelling*, sometimes of a considerable size; the clots it contains

must be cleared away. Extensive tearing with escape of the testicle would necessitate *immediate reduction* with a few fixation sutures (Delorme).

The *testicle*, owing to its mobility and elasticity, often escapes the bullets that go through the scrotum. On other occasions it is excoriated or perforated. The treatment is to reunite the edges of the wound after reduction of the herniated testicular tissue.

The *penis* may be notched or perforated in its cavernous or urethral portions. With the old bullets division of the urethra was scarcely ever noticed. Catheter to be tied in.

The hæmorrhage that follows wounding of the cavernous bodies is not so grave as one might suppose. The consecutive curvature of the penis, which is quite possible, can be treated by later intervention.

CHAPTER XIX

WOUNDS OF THE VERTEBRAL COLUMN AND OF THE SPINAL CORD

THESE wounds are comparatively rare. During the War of Secession only 643 cases were seen, and in the war of 1870 only 289. Yet we have just come across a relatively large proportion of them in the ambulances and hospitals at Nancy.

The tracks of the bullets that strike the vertebral column or the spinal cord are *antero-posterior*, *postero-anterior*, *transverse*, or *oblique*.

The first affect simultaneously the important organs of the face, the neck, the chest, the abdomen, the pelvis. They are exceptional.

The second, less rare, endanger the posterior arches of the vertebræ.

When the axis of the track is median, we find in it notches and perforations of the bodies of the vertebræ or of the apophyses.

Lesions of the Bones.—Bullets *notch the laminæ*, which are really flat bones, *splinter*, *fissure*, *perforate* them, the splinters being either sedentary or thrown forward, and finally *separate* them.

The laminæ, either over or under those that have been directly hit, are sometimes obliquely or vertically fractured by the neighbouring laminæ.

The *spinous processes* present the same lesions.

If these last are carried against the vertebral bodies, their laminæ, or their apophyses, the *strength of the vertebral column is not imperilled*. This fact should be remembered.

Big shell fragments give rise to contusions, fractures, crushing and bony abrasions.

Bullets or splinters may penetrate the vertebral canal.

Meningo-Medullary Lesions.—The *meninges* are generally *perforated* in a linear direction; sometimes they are torn. The *spinal cord* presents very diverse lesions, going from *shock* and *compression* to *contusion* and *wounding*.

Shock is characterized by small apoplectic foci. The distance action of armour-piercing shells lends to this shock a frequency and an importance unknown to our predecessors.

Compression is the result of an effusion of blood either inside or outside the *dura mater*. These compressive *hæmatomata* are *exceptional* in war surgery (Otis). Compression is also caused, but less rarely than by hæmatorrhachis, by the dislocation of a vertebral arch, by splinters, by a projectile, an abscess, a piece of callus (Laurent).

Hæmatic compression, after having revealed its presence by aggravation of the symptoms from the first hours or the first days, *diminishes rapidly and spontaneously*; this shows the uselessness of intervention. Compression due to foreign bodies ends in softening and sclerosis; this shows the utility of intervention.

Contusions have degrees of severity from slight suffusion of blood with superficial dissociation of medullary elements, to attrition, which is localized *in situ*, to the opposite points and to partial destruction.

Wounds are small *punctures*, *grazes*, *furrows*, *grooves* more or less deep, *perforations*, *incomplete sections*, very rarely complete, the result of projectiles or of splinters. Besides, big projectiles may give rise to elongations.

On the level of the cauda equina lesions are very limited. The *spinal roots* are bruised, divided, or reduced to pulp.

Diagnosis of Medullo-Rhachidian Lesions.—The vertebral column undergoes no deformation, but movement is very *painful*, almost impossible. The patient holds himself stiffly.

Sometimes *very slight* pressure allows us to perceive an abnormal mobility and a localized crepitation.

Escape of cerebro-spinal fluid is exceptional.

The functional signs vary according to the seat of the lesion.

Lesions of the *lumbar* spinal cord, which commences at the first lumbar vertebra, may be disclosed by paralysis of the lower limbs, retention or incontinence of urine and of fæces.

Those of the *dorsal* spinal cord by paraplegia, paralysis of the abdominal, dorsal, and intercostal muscles, as far as the limits of the lesion, by recto-vesical paralysis, elevation of temperature, gastric crises, and vomiting.

Those of the *cervical* region by the preceding signs, to which must be added Cheyne-Stokes respiration, hiccough, dysphagia, contraction of the pupils, elevation of the temperature, rapid sacral decubitus.

We will now return to the signs that allow us to recognize *generalized meningeal shock*.

The *meningo-medullary* irritation produced by splinters gives rise to *atrocious pain*, *epileptiform convulsions* (Otis), *contractions of a tetanic form*. This fact should be remembered.

Destruction is known to have happened by signs of deficit.

If we refer to facts cited by Otis, we find that *bullets which compress* and depress the medullary coverings or become fixed in the medulla cause less *acute irritating phenomena than splinters*.

Extensive hæmorrhage outside the dura mater, in cases of common fracture, causes similar pain, though it is less

intense, and appears a little less rapidly and not immediately; but this hæmorrhage is exceptional in the *open* lesions produced by bullets, so that differential diagnosis is not difficult in such cases.

Prognosis.—Spinal traumatisms that have shown resistance to the first symptoms often end happily. The same cannot be said of rather deep medullary lesions. They carry a very unfavourable prognosis. They are nearly always fatal.

The deplorable results following surgical intervention in the Balkan War *command* ABSTENTION in medullary lesions. The focus of a lesion of the medulla is often absolutely impossible to find or to limit; hæmorrhagic effusion and foci cannot be differentiated from damage to the medullary elements themselves; injury, nearly always limited, cannot indicate a suture; finally, a wound of the medulla by projectiles is, so to speak, invariably fatal (Laurent).

Dent's mortality rate of 50 to 60 per cent. in the Transvaal has reference simultaneously to lesions of the vertebral column and of the spinal cord.

Treatment.—*Laminectomy*, that seemed more justifiable than more extensive, more radical intervention, has not given more brilliant results to those who have attempted it than other surgical measures. Nevertheless it is indicated, if not as a regular operation, at least as an atypical operation, in certain cases in which there seem no other means of replacing it with advantage. For instance, when sharp *splinters* forced against the meninges cause atrocious pain; when it is practised in endeavours to remove an *irritating projectile* whose location has been duly discovered; finally, when it is to *facilitate the emptying of an intravhachidian abscess*.

Excepting in these cases, the treatment must be expectant; this, however, does not mean that it should be inactive.

From the field of battle to the first-aid station or to the

ambulance the wounded man, after having been gently raised, should be transported with the greatest care and the most extreme precaution, especially without being jerked.

A soldier hit in the back and unable to move his lower limbs is to be looked upon by the stretcher-bearers as having experienced a fracture of the vertebral column.

His greatcoat must be utilized as a hammock both in lifting him up and in setting him down.

He must not be transported any distance.

The application of Bonnet's hollowed out splint can be of no use, as there is no solution of continuity.

The usual aseptic dressing must be broad. Injections of morphine if necessary. Aseptic catheterism.

In cases of threatened sloughing or of sharp pain coming on at the slightest displacement, lay the patient on a stretcher, the canvas of which has been extensively cut away in a circular form on a level with the soldier's loins and gluteal region. The edges of this opening must be well padded with cotton-wool. The dressings will be kept in place by a large compress going round the patient's back like a hammock, and fixed to the canvas of the stretcher by safety-pins. By this means the dressing can be easily renewed without moving the wounded man.

As a general rule we must refrain from going primarily in search of loose or tolerated splinters, as they are insignificant, and may be useful in the process of repair.

When there is *abundant effusion of cerebro-spinal fluid*, we must put compression on the wound, and suture it if necessary.

The meningeal infection should be treated by lumbar puncture, in case of need by drainage, which must not reach the spinal cord.

In spite of all this necessary treatment, the evolution will nearly always be distressing ; after a few weeks of suffering these patients succumb, if the lesion is high up.

Cerebro-Medullary Shock.—Here we have, as it were, a fresh chapter, which the use of explosive projectiles has lately opened wide, and of which the elucidation was commenced by the surgeons in the Balkan War, particularly by Professor Laurent of Brussels.* We are desirous of drawing the attention of all surgeons in the present war to his work.

We have already seen several cases of this shock in the base hospitals.

This shock may be slight and only manifested by torpor and tingling, specially in the lower limbs, by difficulty in walking, by hyperæsthesia with or without giddiness, by loss of consciousness.

It leaves behind, for a more or less lengthy period, a certain slowness of ideas, a kind of indifference, and retention of urine.

“When of a graver kind, it causes arrest of functions; the wounded man falls into torpor, becomes inert as if absolutely crushed, and all four limbs and the sphincters are paralyzed” (Laurent).

Recovery is rapid in many cases, and occurs in a few days; but paralysis and mental troubles may persist for some time.

These phenomena were observed in soldiers who were 2 to 10 or 15 metres distant from the point where an explosive percussion shell fell and burst, in that angular zone in which the shell fragments follow an ascending trajectory. In typical cases the men have not been struck by fragments of the shell, but they have sustained on the vertebral column, the spinal cord, and the brain, the effects of the excessive concussion—the shock of the column of air which has been intensely and violently displaced. The wind of the shell on other occasions, the contusion brought about

* *The War in Bulgaria and in Turkey: A Campaign of Eleven Months*, by Professor O. Laurent. Maloine, 1914.

by torn-up clods of earth, are the ordinary causes of these effects; but they may also be produced by the direct shock of a shell fragment or of a bullet hitting the vertebral column. Laurent reports a case in which the shock was the result of the grazing of the spine by an intact shrapnel, another in which it was produced by the shrapnel cylinder, and another in which the wounded man remained buried under masses of earth and of stones that had been upheaved by the shell. The cases in this last category are very different, in regard to their mechanism, from the first we have mentioned, which are altogether typical, and in which the shock seems to have been the result of a disturbance produced by the gases and the wind of the big projectile.

In the case of certain wounded men who, knocked over by the gas and wind of the shell, remain on the spot where they fall, it might be difficult to distinguish the psychical from the physical mischief. The symptoms that may be verified can only be attributed to the latter, in cases where these patients—and we have seen a few—have been helped up and taken some distance without again falling on their back.

CHAPTER XX

WOUNDS OF THE UPPER LIMBS

THE new tactics in warfare, which embody prolonged firing from improvised trenches, render the different segments of the upper limbs particularly vulnerable, the result being that wounds of these parts are seen at present with a frequency formerly absolutely unknown. The respective positions of the forearm and of the left arm during firing make these two segments especially liable to simultaneous wounds. The hands also are very frequently hit; and at the time of bursting of shrapnel the fingers are often wounded because they are unprotected on the knapsack, that they hold up to protect the head (French soldiers).

Wounds of the Hand and Fingers.

The hand is the most exposed part of the upper limb. Its lesions are more than 10 per cent. of the wounds of the limb (Ferraton). They are rarely isolated. Concomitant lesions frequently take effect on the head, the face, or the chest.

Wounds of the hands and fingers are *antero-posterior*, more often *postero-anterior*, sometimes *transverse*, exceptionally axial or longitudinal.

Wounds of the Soft Parts.—The *fleshy* parts of the thenar, of the hypothenar, of the metacarpal spaces, *even of the fingers*, are furrowed, sometimes perforated by bullets.

Osseous Lesions.—The *phalanges*, even the second and third, may be indented or perforated. In spite of their small size, they present the typical lesions of fractures of the long bones. On a level with the articulations, radiography shows the epiphysial lesions, perforations with or without separation of small lateral wedges of bone.

On the *metacarpals*, which really are long bones with compact tissue, we see, on the *diaphysis*, oblique or transverse *contact fractures*, also *grooves* and *perforations*, with typical radiating fissures. Perforation of the diaphysis, with its two principal lateral splinters and a few subdivided splinters either free or adherent, are the most common lesions. The splinters are short, rarely displaced. The grooves or the perforations of the *epiphyses* are typical, and the radiating fissures cuneiform.

In the lesions from *postero-anterior* firing, the free splinters are forced towards the palm of the hand. They are very difficult to get at. When the firing is *antero-posterior*, they are superficial; and when they have been forced onwards, they will be found to have *notably* increased the extent of the cutaneous perforation. When the *range is short*, the soft parts of the dorsum of the hand almost present the characteristics of *explosive fire*.

If hit transversely, the hand and the fingers nearly always show *multiple fractures*, which belong to the same type, with, however, the peculiarity that the lesion often increases in size from the first to the last fingers, from the first to the last metacarpal bones through which the bullet has passed.

Complications.—*Hæmorrhage* is the most important and frequent primary complication of these wounds. It is specially profuse when the projectile has penetrated the palm above the horizontal line, starting from the ulnar border of the hand, and going to the inferior border of the thumb in forced abduction (line of E. Boeckel). In this

case one of the palmar arches, sometimes both of them, might be wounded. A diagnosis may be made of a lesion of the deep arch, if the wound corresponds to the bases of the thenar and hypothenar eminences.

Metallic foreign bodies and displaced splinters constitute the second immediate complication. A bullet may stop in a phalanx. The hand being bare, there are *no foreign bodies derived from the clothes*.

Opening of the sheath of the flexor proprius pollicis, and also of the common sheath, which is prolonged to the extremity of the little finger, renders these sheaths liable either to the simple infection of reaction or to suppuration, as well as to the opening up of the sheaths of the finger muscles. Between Boeckel's line and the lower palmar fold of flexion there is a region in which no sheath is reached.

Treatment.—After an application of iodine, a simple dressing is sufficient. The palmar splint, to secure immobility, only seems to be of use when the bones of the metacarpus are very much displaced. However, it is a good plan to often keep up extension of the fingers on account of their tendency to flex and to remain flexed.

After temporary compression, Boeckel's incision and the median palmar incision of Delorme will allow the surgeon to ligature the two ends of the indented or divided palmar arches. Let us remind medical men that our incision extends from the centre of the heel of the hand to above the commissure of the index and middle fingers. By the dorsal route one may, perhaps, after removal of the splinters and of the heads of the metacarpal bones, reach the deep palmar arch.

Our median palmar incision is the best for removal of foreign bodies from the palm, as also for opening deep abscesses. Opening abscesses of the sheaths is carried out either by a thenar incision that opens the sheath of the

flexor proprius, or by a hypothenal incision (internal palmar incision) ; finally, if necessary, by radio-ulnar incisions.

Phlegmonous reactions of the sheaths seem to us much less grave than formerly, and unlikely to necessitate the extensive freeing of the radio-carpal ligament that has been proposed.

Baths of tepid boiled water are always useful in phlegmonous inflammation. Hydrogen peroxide also renders signal service in these cases.

Conservatism is indispensable in wounds of the hand, and, at first, should be pushed to its extreme limits. But care must be taken to employ passive motion to both the wounded and the sound fingers as soon as possible, to avoid the stiffness which is so frequent, so regrettable, and so often ascribed to surgical inaction.

However, if, at the beginning, conservatism should be, so to speak, *excessive*, because the smallest particles of the hand, even if much lacerated, can be of the greatest utility, yet subsequently there must be no hesitation in ridding the patient of *any one of the middle fingers* that happens to be irretrievably ankylosed, both in flexion or in extension, so that it is not only useless, but also troublesome and in the way. Too extensive and too weak terminal cicatrices, as well as painful cicatrices, may also render amputation necessary.

Total removal of the splinters, *trimming the metacarpal fracture* by means of *resection*, are condemned. It may give rise to pseudarthrosis.

Ferraton has very justly said, in speaking of the treatment of the most serious traumatisms (bursting of shells), "the most extensive mutilation of the hand and fingers never can bring about such functional troubles as those that would be caused by total loss."

Self-Mutilation.—In all wars, even during the present one, the question has been raised of self-mutilation carried

out on the hand and fingers. A faint-hearted soldier obtains at the price of self-mutilation the safety of a life which probably was not even threatened.

In such a case *the skilful surgeon must act up to his strict duty. He owes the truth—all the truth—to the commanding officer*; but in order that he may pronounce his verdict, on his soul and conscience, the truth must show itself very clearly; and when he feels the slightest doubt, he must refrain from coming to a conclusion of mutilation.

The frequency of wounds of the fingers and of the hand must not be used as an argument. This frequency is normal in battle during the present wars, as the bare hand is very much exposed to bullets.

Diagnosis is based—On the verification of a palmo-dorsal wound, especially at the extremity of the index and middle fingers; but mutilation may take place in the palm, as we have already seen. The wound in such a case would still be palmo-dorsal. This sign may lead us to a presumption. In battle, wounds of the fingers and hand are generally dorso-palmar.

Formerly a sign that led to presumption was again drawn from the state of the wounds, which were reduced to pulp, irregular, split up; whilst wounds received from a distance are regular. On the other hand, it must be confessed that wounds inflicted for self-mutilation can be regular, and accidental lesions reduced to pulp and lacerated.

The real indication is furnished by the burnt appearance of the aperture of entry. Around the wound, even in all the palm, if this last has been traversed, the epidermis is dry and *black*, the edges of the discoloration being INCRUSTED WITH GRAINS OF POWDER. Even when this has disappeared, grains will be found in the derma.

Chemical analysis of the grains in the epidermis would perhaps remove our last doubts. We are studying this point.

The presence of other wounds is in favour of the man's innocence.

Considering the gravity of the disciplinary decisions that proceed from the surgical verdict, it is indispensable that—

1. In conformity with tradition, the verdict should be given by a *mixed* Commission, composed of surgeons of high rank who are perfectly acquainted with the characteristics of war traumatism, of a few staff officers, and of the Provost-Marshal and his officers.

2. The verdict should be given on a pretty near date to that of the reception of the wound; then all signs are very distinct.

Wounds of the Wrist.

Wounds of the wrist are not very frequent. They are 7 to 8 per cent. in the total of wounds of the limbs.

An inferior, horizontal line passing approximately through the superior and external prominence of the metacarpal bone of the thumb, and a superior line cutting through the forearm at two fingers' breadths above the styloid process of the radius, give the limits of the wrist.

Wounds of this part are *antero-posterior*—these are rare; or *postero-anterior*, which are more frequent, especially on the left side; finally, *axial*, especially on the right. We can easily understand this if we think of the position of the soldier when firing.

Wounds of the Soft Parts.—The soft parts may alone be hit. We have to consider—Tendinous lesions, with penetration of the sheaths; wounds of the vessels and of the nerves.

Osseous Lesions.—When the bones are hit, the lesions differ according to whether the projectile has taken effect on the carpus or on the inferior radio-ulnar extremities.

On the *carpus* we see *indentations* on the edges, extensive *furrows* on the surface, *perforations*, generally simple, all

revealed by localized pain, difficulty of movement; radiographic pictures are rarely conclusive, especially with regard to the *relationship of the track to the affected bones*. Speaking anatomically, these lesions are simple.

Extension or limitation of the damage on the inferior radio-ulnar extremities are governed by the seat of the lesions. The line of the epiphysis and diaphysis rises only a centimetre above the point of the styloid process of the radius.

Below this line the *furrows, grooves, and perforations* are of the *epiphysial* type—that is to say, circumscribed; *above* they are *epiphysial-diaphysial*—that is to say, often radiated by fissured tracks which limit more or less completely wedges that have an articular basis, or large splinters.

From a practical point of view, and in an aseptic wound, these fissures do not constitute a complication.

Diagnosis.—In such a superficial articulation the diagnosis of bony lesions is easy. Localized pain make us suspect fissures, radiography sometimes shows them. Equally easy is the diagnosis of arterial (ulnar, radial) and nervous lesions (median, ulnar, radial).

Treatment.—Hæmorrhage is easily arrested by compression; afterwards by direct ligature, which is indispensable in these cases as a safeguard against a relapse of the bleeding, facilitated by the extensive palmar and dorsal anastomoses.

Possible infection of the sheaths would necessitate dorsal incisions, lateral incisions on the line of the ulnar and radial arteries, or median palmar incisions. Being an uncovered region, the wrist is but little complicated by the presence of infecting foreign bodies.

Conservatism is the rule, even in the most serious traumatisms produced by explosive fire. Immobility is obtained by a palmar splint. Removal of splinters from the carpus, even in infected cases, is rarely of any use, by reason of the

limitation of the damage. Clearing out the wound would only be necessitated by persistent osteitis.

Lesions of the wrist are rarely grave. Passive movements of the articulation and of the fingers should be begun early.

Wounds of the Forearm.

The forearm extends from the superior limit of the wrist to a transverse line, passing two fingers' breadths below the fold caused by the flexion of the elbow.

The proportion of these wounds is not as yet completely established. It is said that they represent a tenth of the total lesions of the limbs.

The tracks may be classed as *antero-posterior*, *postero-anterior* (these are the most often seen), *transverse*, which are pretty frequent, and also the most serious (fracture of both bones), and finally *axial*.

Wounds of the Soft Parts.—Nothing particular can be said on this subject.

Osseous Lesions.—With regard to osseous lesions, they belong to the diaphysial type. They are *contusions*, *cracks*, *fissures*, sometimes revealed by radiography, sometimes by the presence of localized pain (back of ulna); *contact fractures*, often transverse and oblique, or with large splinters; *grooves*, with their well-known lines of fissures; *fractures by perforation*, the most usual.

The adherent splinters are relatively short. The total length of the osseous focus is 4, 6, 8, 10 centimetres. The free splinters are 1 to 2 centimetres longer. Not only in fractures of but one bone, but even in fractures of both bones, there is not always a tendency to an axial or a lateral deviation. But it is a mistake, and we have seen others make it, to treat these fractures by the application of a simple dressing, however thick and permanent it may be. Such a proceeding exposes the wounded man to use-

less pain, to consecutive displacements most regrettable, in reference to the preservation of the shape and the usefulness of the limb. A last reason for the employment of an apparatus is that, whilst rendering the dressing easy, it at the same time safeguards the limb from any circular constriction which would be unfavourable to its vitality.

Complete fractures of the ulna generally show less displacement than those of the radius.

Treatment.—*Immediate* immobility of the forearm can be obtained by a sling, by any splint, by bandages with a straw splint.

We must be careful in applying the dressing not to exert too strong a circular or interosseous constriction, as this might cause gangrene.

Immobilization should be obtained with the forearm in the position of *supination*; the fragments then will be in good position. In half pronation or in complete pronation, these fragments cross one another, and their extremities are directed towards the axis of the interosseous space (Ferraton).

Our *hollowed out metallic splint with valves* insures the easy application of the dressings, it enables us to exercise supervision, to push back towards the axis, if necessary, the lateral splinters when they are displaced from the centre, besides, in our hollowed out splint, supination is the natural position.

The splint should be long enough to include part of the arm and the hand, so as to immobilize both the elbow and the wrist.

Antero-posterior or lateral *deviations* (the last are the most serious, especially of the ulna) are the result of the fragments over-riding, and should be prevented. Pseudoarthrosis exposes the limb to the same danger, and pseudoarthroses are not rare in the forearm. They are nearly always consecutive to unjustifiable removal of splinters,

therefore we must absolutely abstain from doing this, at least at first.

In fractures of both the radius and the ulna, as a consequence of the isolated synostosis of the upper fragments, then of the lower, the movements of pronation and of supination are lost.

In order to reach wounded vessels we must make use of the classical incisions. They should also be utilized in searching for foreign bodies, and in opening purulent collections.

Conservatism must be pushed to its extreme limits. This is the occasion to repeat that *whatever the extent of a traumatism due to a bullet, conservatism should be carried out as long as there is no confirmed gangrene.*

PROGNOSIS is generally very good, even when the fracture is of a complicated type. For this reason we should most carefully endeavour to obtain a perfect ultimate result.

We need not stop to consider the consecutive nervous and osseous complications.

Wounds of the Elbow.

The elbow is the region comprised between two transverse lines passing at two fingers' breadths, 4 centimetres above and below the fold of flexion.

Its wounds represent one-tenth of the lesions of the upper limb, and 3 per cent. of the total.

The tracks of the bullets that reach it are nearly always *antero-posterior*, more rarely *postero-anterior* or *transverse*.

Wounds of the Soft Parts.—The only point of interest in wounds of the soft parts lies in lesions of the vessels, hæmorrhage from the brachial, from its *venæ comites*, from the superficial veins, and in lesions of the nerves (median, ulnar, radial).

The classical incision for ligature brings the surgeon on

to the brachial artery. If it has been divided, the only efficacious plan, in order to prevent blood coming back through the inferior end, is to ligature both ends.

Osseous Lesions.—Osseous lesions should be studied on every bone of the part.

With reference to the elbow, as in dealing with all joints, we have concisely laid down what damage is caused by bullets on the *extremity of the humerus*, on the *radius*, and on the *ulna*.*

On the *epicondyle* and *epitrochlea*, which are but super-added epiphyses, the *grooves*, *perforations*, and *abrasions* that we see are limited lesions.

On the *trochlea* and the *condyle*, the damage caused by bullets whose track is situated *below the epicondylar line* is limited. It is rare for this damage to extend above this line. With regard to the nature of the lesions, they are *clean fractures*, *furrows*, *perforations*, *abrasions*; the perforations are nearly always not, or but little, comminuted. From transverse fire the lesions are more important. Generally they are simple.

When the bullet penetrates *on the level* of the epitrochlear-epicondylar line or *below* it, the lesion is of the epiphysal-diaphysal type—that is to say, the perforation is accompanied by more or less complete fissured tracts, which are prolonged as much as 5, 6, 7 centimetres above the intervening line, forming nearly always two lateral splinters, which, lower down, enclose a large subperiosteal adherent fragment represented by the condyle and the trochlea. The fracture, whether incomplete or complete, is therefore supracondylar. A secondary fissured tract may make it supra- and inter-condylar.

On the other hand, if the firing, instead of being median, is lateral, only one fissure is found which limits an adherent internal or external *condylar fragment*.

* E. Delorme, *Treatise on War Surgery*, p. 296 et seq.

A bullet that penetrates *to the limit of the olecranal and coronoid cavities*—that is to say, to two fingers' breadths from the epitrochlear-condylar line—causes a *typical diaphysial fracture*.

The head of the radius, the coronoid process of the ulna, the upper half of the olecranon, are composed of pure superadded epiphysial tissue. Their lesions are limited.

The bullet that penetrates below the head of the radius to the base of the olecranon, and, *a fortiori*, below it, gives rise to one or two radiating cuneiform fissures, with a superior base and an apex descending to 3 centimetres below the intervening line.

Diagnosis.—The diagnosis, clinically based on the relations of the track to the osseous extremities with which the projectile comes into contact, is at first easy, before the rapid swelling that comes on in this region has set up. But it is necessary, in order that the diagnosis may be precise, for the two segments of the elbow to be replaced, at any rate in the surgeon's mind, in the position they occupied at the moment of the traumatism. Pain, revealed by pressure on the course of the fissures, is a good sign. Radiography will complete the first data.

Treatment.—*All bony lesions of the elbow, when caused by bullets, should be treated at first by conservatism*, whatever be the comminution, whatever the extent of the damage to the soft parts, even if the brachial artery is involved and the nerves contused. We have proved this in an admirable example we brought before the Academy of Medicine.

At first a sling, a short time afterwards a hollowed out valvular metallic splint, which takes as points of support the arm above and the forearm below, leaving the elbow free, will insure immobilization. A plaster apparatus is not as advantageous as this splint. It is more prudent to secure this immobilization even when there is no abnormal mobility.

Superficial antiseptics with immobility generally suffices to secure recovery. When there is suppuration, the necessary incisions must be made at once.

Superficial and anterior abscesses are opened by the incision that is utilized for ligature of the brachial artery, posterior ones by an axial incision, which, if necessary, will also open the bursa of the olecranon, where suppuration is often started by a slight lesion.

To get to the joint we must have recourse to a posterior, median, supra-olecranal incision, or to a lateral internal short incision skirting the inner border of the triceps and stopping below at the epitrochlea, so as not to wound the ulnar nerve; finally, to the lateral external curved incision used for resection.

Removal of *perfectly free* and infected fragments can be accomplished through these incisions, and drainage can be established from one wound to the other.

If, by reason of the grave nature of the lesions and the slowness of the cure, we apprehend ankylosis, the limb must be placed in a position of flexion at a slightly acute angle, in preference to a barely acute one or to a right angle (Ferraton). The first position is the only one that allows the patient to carry his hand freely to his mouth. The forearm will be in a position midway between pronation and supination; the hand should have the thumb upwards.

Ankylosis is relatively frequent after bullet wounds, for the elbow is a very tight ginglymus that stiffens quickly, and rapidly loses its action without passive movements. Therefore, when there is no suppuration, we must not wait too long before beginning these movements.

Atypical resection should be exceptional; it must only be undertaken at a subsequent period if there is prolonged osteitis.

Wounds of the Arm.

From the elbow, whose limits we have given, the region of the arm extends above to a horizontal line which should just touch the inferior border of the pectoralis major.

Wounds of the arm, like those of the forearm and of the elbow, are sometimes isolated, sometimes complicated by simultaneous lesions of the neighbouring parts—the head, the thorax, the abdomen.

Wounds of the *soft parts* do not call for any special practical consideration. They are sometimes extensive both in front and behind the limb when caused by large shell fragments.

Osseous lesions of the diaphysis of the humerus are typical. They are *contusions* ; *longitudinal fissures* ; *fractures by contact*, either transverse or oblique, with large splinters ; *grooved fractures*, with their well-known fissures ; *fractures by perforation*, of which the type with two lateral splinters, more or less subdivided, is habitual. In this last lesion the focus of free splinters, that are generally short, usually corresponds to the bony focus of exit, and extends but little.

Splinters adherent to the periosteum are from 6 to 8 centimetres long. The close relationship of the musculo-spiral nerve (*in French, radial*) to the diaphysis of the humerus is the cause of this nerve often being contused or torn in the fractures.

Treatment.—*Conservatism is the rule in all fractures of the humerus by bullets.*

If immobilization is well insured by Champenois's hollowed out splint, or by a hollowed out metallic splint framed on Hennequin's model, it will be found that application and renewal of the dressings with these apparatus are less easy than with the hollowed out *valvular metallic splint*. Preference, then, should be given to this last apparatus

In some fractures of the upper fourth of the humerus, in which one has but little power over the superior fragment, as it has a tendency to abduction, reduction and regular maintenance of reduction is only obtained by also giving the inferior segment an inclination to abduction. This position is maintained by a big triangular pad fixed against the thorax, with its apex in the axilla, and against which the apparatus and splints rest. These cases are rare.

In complete fractures of the lower part, the point of the inferior fragment has often a tendency to fall forwards. The fracture is reduced by a localized external compression.

In the largest majority of cases, maintenance of the reduced fracture in an axial apparatus will suffice, for the displacement of the fragments is either non-existent, or very moderate and easily reduced.

Whether the axial or lateral displacements are to be reduced or are non-existent, the whole limb must not be too much moved.

The lateral splinters, the *free* splinters, must not be removed at once, but should be carefully brought nearer the extremities of the fragments, whilst resting in the apparatus, through pressure exerted by elastic tampons of cotton-wool applied perpendicularly to the course taken by the projectile. Repeated radiographic examination will give the requisite information on the result obtained, and on the one that we must still hope for.

When the wound is properly treated and suppuration has been trivial, recovery is generally very rapid—often it is obtained in nearly as short a time as would be necessary for the consolidation of a simple fracture.

In infected foci purulent collections should be at once opened by *lateral incisions*—either the internal incision along the internal border of the biceps is employed, or the external incision along the external border of the triceps. The musculo-spiral must be avoided.

We have nothing special to say with regard to lesions of the arteries or of the nerves, to aneurysms, to liberation of the musculo-spiral, which is so often included in callus, to the removal of foreign bodies, to foci of persistent osteitis which we get at by lateral incisions carried to the level of the intermuscular septa. Let us remind surgeons that the external incision, in order to avoid the musculo-spiral, must stop below at 10 centimetres from the epicondyle, and also that subsequent ligation of arteries generally necessitates free incisions.

Wounds of the Shoulder.

Wounds of the Soft Parts.—Amongst the wounds of the shoulder we only have now to study those in the region of the deltoid, of the axilla, and of the articulation. Lesions of the clavicle and of the body of the scapula have been described in the chapter on wounds of the chest.

2.9 per cent. of the wounded men are hit in the shoulder.

Bullet wounds of the axillary or deltoid regions present nothing in particular. Fragments of large projectiles sometimes give rise in these localities to very extensive loss of substance, without, however, opening the joint.

Opening of the large subdeltoid serous bursa is of no importance so long as the wound remains aseptic. When it is infected (shrapnel bullets, shell fragments, deflected bullets), a rapidly developed abscess is the result.

A bullet may pass between the acromion and the articulation without opening the joint.

We should only be saying the same things over again if we dwelt on the characteristics and the prognosis of lesions of the axillary artery and vein. These large vessels give rise to formidable primary and secondary hæmorrhage, to arterial and arterio-venous hæmatomata, that necessitate, in the hands of an experienced surgeon, subsequent difficult

operations. Primary or secondary hæmorrhage must be treated by direct ligature. Indirect ligature of the sub-clavian fails in two-thirds of the cases.

The nerves of the brachial plexus, the circumflex nerve, are, like the important arteries, either wounded separately or at the same time as the bones.

Osseous Lesions.—On the superior extremity of the humerus, the growing or epiphysial cartilage, that differentiates lesions of the head of the bone from those of the remainder of the articular extremity, corresponds to the anatomical neck. The tuberosities are superadded parts that are developed from special bony points, and that retain their individuality with regard to their wounds.

HEAD OF THE HUMERUS.—1. Bullets that, above the cartilage of the anatomical neck, reach the head of the humerus, cause *furrows, hollowing out, simple perforations*, or may break it up. This last is rare, but even in such cases the fragments remain in contact.

2. If the projectile penetrates at *the level of the anatomical neck*, about its centre, the head of the bone is separated from the shaft by a fissure, but nevertheless it remains very adherent, thanks to the fasciculi of fibrous tissue about it and the periosteum.

3. If the penetration of the bullet has taken place near the *greater tuberosity*. This latter is separated by a *wedge-shaped* fissure, with the base uppermost, but the fragment, which has fixed limits, is very adherent.

4. *Under the anatomical neck, on the surgical neck*, the lesion is *epiphysial-diaphysial*; the fissures may be extended.

5. The *greater tuberosity* is excavated as by a groove, superficially perforated or deeply perforated. The lesion is limited to the tuberosity when the firing has been antero-posterior. If it has been transverse, *the bullet has followed an epiphysial-diaphysial track*, and has led, on the head of the

bone and on the diaphysis, to the formation of two large lateral splinters.

6. The lesser tuberosity may be *abraded*.

GLENOID CAVITY.—In the glenoid cavity we observe furrows, simple or fissured, perforations. The fragments are nearly always held in place by the insertions of the capsule.

Diagnosis.—Lesions of the shoulder-joint, by reason of the great thickness of the soft parts covering it, and of the extensive swelling which sometimes very rapidly invades the region, should be diagnosed especially by taking into account the seat of the wounds and their relationship to the points occupied by the extremity of the humerus and by the epiphysal-diaphysal line. Wounds of the glenoid cavity can only be suspected without the help of radiography.

We have given very precise data for insuring the diagnosis of lesions of the upper end of the humerus.

IN FRONT.—By moderately strong pressure we can recognize the *tip of the coracoid process* in the deltoid-pectoral space. From this tip we drop a vertical line. *The inferior limit of the anatomical neck of the humerus is, on this vertical line, a finger's breadth below the coracoid tip and a little internal to it.*

If from the most prominent, *the most external, part of the acromion* we draw a line which ends at the point previously fixed, the resulting oblique line gives the *direction* and the *seat of the anatomical neck*.

With the arm falling vertically, we can make out the rounded head of the humerus above this line; the lesser tuberosity and the diaphysis are below it.

AT THE BACK.—If we unite the same acromial point to the *prominent angle of the scapula*, with the arm falling vertically, we mark out *the line of the anatomical neck*.

Its inferior limit is where the *preceding line intersects a vertical line dropped from the acromio-clavicular articulation*, which can

be recognized by the prominence of the outer extremity of the clavicle.

If the line of the neck be carried backwards, we make out, above it the head, and below it the remainder of the humerus, in the same way as in front.

With these data, confirmed by radiography, it is easy to recognize the bony points that have been wounded. Our anatomical and pathological knowledge will indicate the character, the limits, and the extension of the lesions.

Treatment. — *Conservatism is the rule in lesions of the shoulder. It is primarily applicable in nearly all injuries caused by bullets, even in the most serious ones.*

Amputation would only be justifiable in *confirmed gangrene*. Immobility is at first obtained by a sling and by fixing the arm to the body. Subsequent immobility and keeping in position necessitate the employment of other methods. A hollowed out splint is one of the best apparatus.

The ordinary hollowed out splints made of iron wire are detestable; their equilibrium is unstable, they get out of place, forcing the patient to stiffen himself to keep them from falling off, or to constantly hold them up with his hand; besides, they do not allow an easy application of dressings. Hennequin's hollowed out plaster splint, Champenois's splint, and, above all, our *hollowed out splint with valves*, lengthened out when necessary, in certain cases, in order to cover over the whole shoulder, are preferable.

Extension is necessary in some fractures of the surgical neck, but these cases are rare. Our apparatus, which exerts counter-extension in the axilla and extension on the elbow, realizes these desiderata with great simplicity. A few notches are made in the part of its upper edge which rests in the axilla; the flaps thus formed, that correspond to the armpit, are evenly turned down and well padded. A spica bandage of the neck and the axilla is then put on; it firmly fixes the apparatus above, and gives it a power of

counter-extension. Extension is made on the elbow by bandages.

In infected wounds, abscesses under the deltoid must be opened in front by the *anterior vertical deltoid incision* used in excision, carried a little outside the deltoid pectoral line. Behind a symmetrical incision may be made, but it must not descend more than 4 centimetres below the acromion, so as to avoid wounding the circumflex nerve.

Collections of pus in the axilla are incised behind the inferior border of the pectoralis major; periscapular collections along the spinal border of the scapula, and the incision is followed, when necessary, by freeing of the bone with the finger.

Removal of splinters that cause intolerable suffering will be done through the same routes.

Atypical excision is quite allowable, but only at a future period and in cases of persistent osteitis.

The grave disturbances caused by shell fragments may necessitate a *disarticulation*. We must bear in mind that a disarticulation of the shoulder can be done by placing the knife almost exactly under the acromion (Ledran), and in this way that an excellent stump can be made. The typical intrascapular thoracic disarticulation is, so to speak, never indicated.

CHAPTER XXI

WOUNDS OF THE LOWER LIMBS

LESIONS of the lower limbs are about two-thirds of the total wounded (Ferraton).

Wounds of the Soft Parts.

Before speaking of the wounds caused by weapons used in warfare, let us call attention to the oedema seen in men who are obliged to keep on their bandages (puttees) for too long a time ; also to the *ulcerated blisters* on the sole, on the posterior part of the foot, regions that correspond to the tendo Achillis, to the malleoli, these excoriations being so frequent that formerly at the beginning of a campaign it was admitted that a fifth of the strength of an army was rendered unavailable through this cause. When badly treated, these excoriations give rise to reticular lymphangitis of the foot, which extends to the leg, and is too often followed by abscesses and diffuse putrid phlegmonous inflammation. Military surgeons cannot pay too much attention to the question of these complications, which cleanliness of the feet, inunction with some fatty body, employment of alum, formol, picric acid, or iodine, may prevent or mitigate.

We may also mention *peritendinous cellulitis of the tendo Achillis* and *twisted foot*—which is only a metatarsal fracture (Pauzat).

The foot is very frequently hit by projectiles, *as often as the thigh*.

The track is *dorsi-plantar*, *planti-dorsal*, or *transverse*.

Lesions of the Bones—**TOES**.—Notwithstanding their small size, the toes are diaphysial bones. Their epiphysis may be hollowed out into a groove or perforated. When the diaphysis is hit, the groove and perforation are clean, or may be prolonged by fissures. These lesions are very small, even when present simultaneously on several toes.

The **METATARSALS** are diaphysial long bones with very compact tissue. Their lesions show on the body of the bone the classical characteristics of transverse and oblique *contact fractures*. They are very frequent. *Grooves* are found, also *perforations* of the usual type with lateral splinters. The free splinters are small; the adherent ones are only 2, 3, 4 centimetres long. In transverse fire, several metatarsals, specially those at the extremity of the arch of the foot, are fractured. Subdivision of the splinters is greater in the last bones hit. The metatarsal epiphysial extremities present typical epiphysial lesions, without splinters.

The **BONES OF THE TARSUS**, in spite of the variety in their shape, present *grazes*, *furrows*, *tunnelling*—regular canals without fissures or noticeable splinters.

By reason of its size, its structure of oblique fibres directed from below and from the back of the bone, we see in the *os calcis* tunnellings often accompanied by radiating open fissures, or rather fissures directed in an oblique way with regard to its fibres. The *splinters limited* by these *fissures are generally adherent*. We will deal later on with the lesions of the astragalus.

Diagnosis.—The diagnosis, based on the relations of the track to the bones it meets, is usually easy to the surgeon who is well acquainted with the anatomy of the foot. It is afterwards completed by radiography.

Complications.—Wounds of the foot possess but little

surgical interest excepting through their complications—*hæmorrhage, foreign bodies, infection, tetanus.*

Hæmorrhage comes from the *dorsalis pedis* artery or from the two *plantar* vessels, especially from the external, which is larger and longer than the internal. The *dorsalis pedis* has a well-known course. That of the *plantar* arteries is not so familiar. We have already described it, and we will again call it to mind.

If, on the sole of the foot, we draw (1) a vertical line starting from a point on the centre of the heel, and going to the interdigital space that separates the fifth from the fourth toe, and (2) a line starting from the inner fourth of the heel, and going to the first interdigital space, these lines will give the direction of the *two intermuscular septa, internal and external.* Now, these septa divide the sole into *three parts*—the external, the middle, and the internal.

The *external part contains no important vessels.*

In the *internal part* runs the *internal plantar artery*, which becomes unimportant after reaching the metatarsus.

In the *middle part*, the *external plantar* describes a curve with an external convexity, which terminates at the bases of the central metatarsal bones. The result of this arrangement is that the external part and the metatarsal region can be traversed without danger to any important vessels, and that, with regard to *hæmorrhage*, lesions of middle part, and, in some measure, of the internal part, are the only ones to take into consideration.

A deep incision, of an appropriate length, which pushes aside the flexor brevis digitorum immediately inside the external intermuscular septum in the region of the tarsus, allows us easily to find the external plantar artery and to ligature it. (External plantar incision, Delorme.)

A tarsal incision inside the internal intermuscular septum allows us to find the internal plantar and ligature it. (Internal plantar incision, Delorme.)

A skilled surgeon will utilize these direct incisions to put an end to plantar hæmorrhage. Others will employ immediate compression after incision or mediate compression without incision, hæmostatic proceedings that are rendered very useless by the wealth of anastomosis in the part.

The exploratory incisions we have described govern all the necessary surgery to deal with complications in wounds of the foot. They lay bare the vessels; they enable us to search for metallic foreign bodies; they also give an outlet to the discharge of plantar abscesses, almost exclusively localized in the middle part, before described, and which are pretty frequent owing to the dirt on the sole of the foot and on the pieces of the patients' socks and boots, these fragments having been carried into the wound, owing also to the sheaths of the tendons having been opened (deflected bullet, shrapnel bullet). Again, it is by the help of these incisions that we remove splinters that have been forced forward and are badly tolerated. They are the result of a bullet with a dorso-plantar track.

Tetanus is a rather frequent complication of these wounds.

Treatment.—Wounds of the foot very often end in recovery, and this is nearly always brought about by simple treatment—application of dry dressing, rendered antiseptic by iodine—and immobilization. Wet dressings must never be applied. On the foot they are absolutely *pernicious*.

The dressings, if they are thick enough, will themselves insure immobilization. It is only when the firmness of the foot is jeopardized by an extensive fracture that we should have recourse to an immobilizing apparatus.

A very bad practice, and one that is too much followed, consists in letting these patients walk whilst they are suffering from bone lesions of the foot. Their cure is thereby much retarded, and they are thus exposed to complications. All walking on the wounded foot should be forbidden for a

long time, but this does not mean that the surgeon should abstain from utilizing passive movement.

Amputation is only admissible at first as a standard operation in very vast shattering transverse lesions the result of shell fragments. The technique of these operations can be simplified if the foot is considered as being formed of only one bone (Mayor).

Although *primary conservatism must be the rule*, we must not hesitate at a *later date* to rid the patient of deflected troublesome toes, and even of the foot, if it has become very much deformed, and inconveniences the man when he walks, and whose deviations we have been unable to correct by anastomosis of tendons, by tarsectomy, or by arthrodesis (Syme's operation).

Wounds of the Instep.

From the subastragalar articulation, the instep extends to 3 centimetres above the tibio-tarsal interspace.

Wounds of the Soft Parts.—Indentations, perforations of the tendo Achillis and of the anterior and posterior tendons, opening of their sheaths, wounds of the anterior and posterior tibial arteries and of their accompanying nerves, represent the most interesting lesions of the soft parts of the instep.

Large shell fragments may become lodged between the tendo Achillis and the deep parts.

Lesions of the Bones.—The ASTRAGALUS may be *eroded, hollowed out into grooves, or perforated*. In anterior-posterior fire, perforation may be accompanied by separation of the bone into two parts. In transverse fire the neck may be divided. Fissures of the remainder of the bone are vertical or radiating.

Perforation is generally clean, and, thanks to the strength of the ligaments that are inserted into three of the surfaces

of this bone, the fractured fragments remain in contact, even if the fissures are deep.

On the TIBIAL EXTREMITY the lesions are rarely of the epiphysial type, because the level of the cartilage of growth is only *a centimetre* high. So that in the perforations, which are the usual lesions, fissures are often seen, although they do not practically complicate the traumatism. These fissures form the limitations of *wedges* at the periphery of the bone, or else are radiated.

The EXTERNAL MALLEOLUS is hollowed out as with a gouge or perforated. At 1 centimetre above its base the lesion takes on the diaphysial type. It is always simple.

Diagnosis.—Generally, diagnosis is easy, in spite of rapid and sometimes considerable swelling. It is based on the relationship of the wound to the articulation.

Treatment.—Hæmorrhage from the tibial arteries renders compression necessary, then ligature. Suppuration that has a synovial origin readily diffuses to the dorsal surface of the foot, to the anterior surface of the leg, to the plantar region, to the posterior surface of the leg. Incisions, as for ligature of the tibial arteries, or our external plantar incision, are indicated.

Primitive conservatism is the rule in osseous lesions of the instep by bullets, and we may call its indications absolute.

Immediate immobilization is obtained by the wounded man's boot; this is replaced by a temporary apparatus, and finally, as soon as possible, by a gutter-like splint with a movable plantar portion similar to that in Raoult Deslongchamps's hollowed out leg-splint and in our own apparatus. We cannot imagine employment of any other apparatus. In any case, none other facilitates to the same extent subsequent inspection of the limb, application of dressings, and performance of any necessary intervention.

Vigilant watching of a region so easily infected as that of the instep should be incessant; the same may be said with

regard to the foot. On the first threat of suppuration incisions must be made at the points we have indicated.

Suppurative arthritis will be treated by vertical anterior incisions following the borders of the internal and external malleoli. Infected splinters whose presence cannot be tolerated should be removed through these incisions, or through those of astragalectomy.

Primary removal of splinters is condemned.

In those cases where the lesions that can be seen give us cause to fear consecutive deviation, we should prolong the immobilization of the foot in a good position—that is to say, in flexion, not at a right angle, but at a slightly acute angle.

Cure of bullet wounds of the instep is very common, and is obtained without much difficulty.

Wounds of the Leg.

Wounds of the leg are pretty frequent. Fractures of the leg represent *a quarter* or *a third* of all fractures.

Wounds of the Soft Parts—The only wounds of this kind that deserve mention are *extensive setons*, the *culs-de-sac*, very often infected and giving rise to abscesses that must be opened at once, or we risk their diffusion; finally, the *simple perforations* of the *interosseous space*, with wounding of the tibial arteries and nerves.

Antero-posterior and postero-anterior bullet wounds do not seem much more frequent than the transverse.

Lesions of the Bones.—The FIBULA, after tangential fire, often exhibits *transverse* or *oblique fractures*.

Nearly always on this bone we see *grooves* and *perforations*. The former are simple—that is to say, they may consist of mere notches (indentations of the edges), or they may show at the same time the notch and a transverse or oblique fracture, or one with long splinters.

Perforations with adherent splinters 4 to 6 centimetres long, and short, free splinters are common.

TIBIA.—On the tibia we may see with remarkable clearness all the varieties of diaphysial lesions.

Contusions are very frequent. On the inner surface of the bone they are evident.

Longitudinal *fissures* may groove one surface or the three surfaces of the bone.

Transverse and oblique fractures by contact are seen on any part of the bone, but specially at the lower third.

Contact fractures with large splinters, either of a simple or a comminutive type, may be observed at all parts of the bone.

Only a few examples are cited of *perforation* of only one side of the bone. The most usual osseous lesions are *grooves with adherent splinters*, and especially *through-and-through perforation*.

The type of perforation is always the same whichever surface of the bone is hit.

The *adherent* splinters of the perforation are often a third or a half as long as the bone. The free splinters are relatively large and big. They are 1, 2, 3 centimetres in length.

When the aperture of exit corresponds to the inner surface of the tibia, and when the bullet that produced the lesion has had a high velocity, the burst skin presents a big breach.

Simultaneous lesions of the tibia and fibula return to the usual types. The second bone hit presents a more comminuted fracture than the other bone.

All these fractures are with or without displacement. Generally the displacement is very slight.

Diagnosis.—The diagnosis is easy, and can be established by the help of the ordinary signs.

Treatment.—*Hæmorrhage* and *hæmatomata* are frequent complications (one-tenth) of wounds of the leg. Pushing forwards of the splinters is not unconnected with their

frequency, as they are seen *four times more* often in cases of fracture than in wounds of the soft parts.

Either distant or mediate compression is the immediate treatment, direct ligature the *surgical* treatment.

When uncertain as to which of the posterior vessels has been damaged, we should make an axial incision which will allow us to reach both the posterior tibial and the peroneal arteries. We must not fear to freely relieve constriction by incisions, and here, as elsewhere, we must apply ourselves less to directly recognize the vessel, which is masked by the blood, and difficult to identify and to take up because its continuity has not been interrupted—than to discover the *accompanying nerve*. Once this last is found, the artery can easily be freed.

Abscesses should be opened through the incisions which would be employed to ligature the arteries.

The same incisions will serve also in the subsequent search after deep and badly tolerated *foreign bodies*.

Immobilization is obtained on the field of battle by fixation of the HEALTHY leg against the wounded leg.

A good temporary apparatus can be made of straw, covered with canvas, and used as bandages.

Ultimate apparatus may be of pasteboard, plaster, or zinc, framed on Raoult Deslongchamp's model, etc.; the best undoubtedly are the valvular metallic splints, hollowed out like a gutter. Our conviction on this point is stronger than ever. The use of these splints should be made general. No other keeps the parts in such good apposition, renders the dressing so easy, facilitates the bringing together of displaced splinters and the supervision of the limb. We have witnessed most deplorable displacements in fractures treated in hollowed out splints of iron wire, which quite wrongly are very much used, and we have many times verified and heard, mentioned the difficulties that these

splints and plaster apparatus make the surgeon experience in the application of the dressings.

Apparatus for continuous extension can only very rarely be indicated, and those to aid walking are not often of use in our traumatisms.

When the fibula alone is wounded, the tibia serves as a splint.

We must do our best to obtain very satisfactory definite results, to avoid callus with angular points in front or at the back, especially lateral deviations, axial rotation, stiffness of the knee and of the instep. We must make a point of frequently ascertaining that a line starting from the first interdigital space cuts through the centre of the patella to get to the middle of Poupart's ligament. This line is that of the limb's normal direction.

We will not speak of the nervous lesions or of osteitis. *Primitive amputation is contra-indicated in bullet wounds*, unless the case be one of confirmed gangrene.

It is only admissible as an atypical operation to deal with a large wound that has been torn by shell fragments, and shows lesions of the vessels and of the nerves.

Wounds of the Knee.

The knee is comprised between an inferior transverse plane, passing through the anterior tuberosity of the tibia, and a superior one cutting through the thigh three fingers' breadths above the upper border of the patella.

Traumatisms of the knee caused by projectiles are very frequent (one-third of joint wounds, 3 per cent. of all wounds). Penetrating wounds are more often seen than non-penetrating.

Peri-articular Wounds.—These are nearly always posterior lesions, whose gravity consists entirely in wounds of the large popliteal vessels and nerves.

Wounds of the popliteal vessels give rise to very severe

immediate hæmorrhage or to arterial hæmatomata, that endanger the limb's vitality and are very difficult to treat.

Compression at a distance does not securely arrest the hæmorrhage, *mediate compression* is prejudicial to the collateral circulation. *Direct ligature* is the sole surgical treatment; but where is it to be applied, and how many surgeons could perform the operation? All these conditions make the prognosis of these wounds essentially gloomy.

These wounded men, threatened with gangrene, must remain on the spot, and we may look forward to have to perform amputation of the thigh after a very short delay, so soon as we see the first signs of gangrene, if direct ligature is impossible.

Popliteal hæmatomata are sometimes enormous; they invade the whole of the popliteal space, the leg, the thigh, being too often preliminary to gangrene and to diffuse suppuration. On other occasions the situation is quite different: the hæmatoma is circumscribed, and comes on late (arterial contusion). Direct intervention, to be of use, must treat the collateral circulation with caution, and no dissection should be carried out.

Wounds of the internal popliteal nerve that involve its whole thickness do not imperil the function of the most important muscles of the leg, whilst the foot, that does not undergo lateral deviation, can be very useful even after complete section of this nerve. Walking is quite possible and is steady.

Section of the *external* popliteal nerve, on the other hand, gives rise to very much greater inconvenience, yet the patient may still manage to walk with the help of an orthopædic boot (Letiéviant).

Wounds of the Joint without Osseous Lesions.—They are pretty frequent, and are produced by a bullet penetrating under the tendon of the quadriceps, going across the cul-de-sac beneath it, perforating the articulation, whilst

the knee is flexed, and penetrating in the middle line under the apex of the patella. Such are the most common simple articular lesions.

Wounds of the Joint with Osseous Lesions.—The borders of the PATELLA are *indented*, its surfaces *hollowed out as with a gouge*; the bone is *perforated* from before backwards or transversely, cleanly, or with fissures. GENERALLY THERE ARE NO SOLUTIONS OF CONTINUITY.

FEMUR.—Lesions of the femur vary according to the part hit.

The line of the growth cartilage on this bony extremity corresponds to the base of the condyles. From this line the fibres ascend vertically, joining the body of the bone by the most direct and the shortest route. A bullet penetrating *below* the line of the cartilage gives rise to lesions of the *epiphysial* type; if it penetrates *above* the line, it produces lesions of the *diaphysial* type.

On the condyles of the femur the lesion consists of *contusions, furrows, peripheral perforations*, with fissures of the external shell; of *more central perforations*, either clean or with rare separation of fragments. These fragments show different shapes; they are in juxtaposition or in dissociation. Even in such cases the lesion is usually simple.

If the bullet penetrates *at the base of the condyles*, it not only produces a perforated track, but it gives rise to fissures that imperfectly separate long *external or internal wedges*, either adherent or movable in antero-posterior fire, and *anterior and posterior wedges*, either adherent or movable in transverse fire.

TIBIA.—*On the tibia the line of the cartilage is only a centimetre beneath the articular interspace.* From this line the osseous fibres descend directly towards the surfaces of the bone. Lesions without fissures are therefore shallow, inter-articular furrows, more rarely perforations. Most of these last are accompanied by fissures that limit external or

internal *cuneiform fragments*, whose points are downwards ; they are more or less adherent. This does not complicate the lesion when recovery takes place without suppuration.

FIBULA.—On the upper extremity of the fibula lesions are simple (erosions, grooves, perforations). These last are more or less comminutive.

Diagnosis.—We must hardly expect to diagnose articular penetration by the outflowing of synovia. It is generally absent. We have only seen it once in about ten penetrations. On the other hand, opening of the periarticular serous membranes gives rise to it. *Hæmarthrosis*, coming on rapidly, is a better sign to go by. It is common. But the relationship of the bullet's track to the different parts of the bone will often allow us to establish a localized diagnosis.

Later on *pain* along the fissures, or *prominence* of the extremities of the cuneiform fragments, and finally radiography, will all share in the diagnosis.

Prognosis.—We have pointed out that the thick adipose cushion which protects the synovial membrane often brings about in front of the femur occlusion of the osseous orifices that the soft parts obturate at the back. On the other hand, the present bullets, very much more than the old ones, separate rather than penetrate the vertical fibres of the capsule over the patella. The fibres of its ligamentous covering, being simply separated, stop up the wound in the bone. These are very favourable conditions for recovery. And there are still others : the narrowness of the wound ; the rarity of the driving forward of foreign bodies derived from the clothes when the bullet is fired at point-blank range. With reference to this, there is a very different prognosis to establish between wounds thus made and those resulting from deflected bullets or from shell fragments, that so often carry with them very infective pieces of clothing.

Formerly septic evolution carried off rapidly three-quarters

of the soldiers wounded in the knee. Diffuse abscesses appearing very quickly, suppurating arthritis with crural and popliteal fistulæ, were only preliminaries to septicæmia. Femoral or tibial osteomyelitis completed the series of the sources of infection. Nowadays a very large majority of these wounds recover without any trouble. From 11 per cent. during the Russo-Turkish War, the mortality fell to 4·5 in Cuba. Not only is recovery the rule, but it is obtained nearly always without loss, or, at any rate, without notable loss of the movements of the knee. This prognosis, favourable both relatively and naturally, must not make us forget that great attention, the closest supervision, are absolutely necessary in these cases, besides the skill which is requisite in their treatment.

As a principle, wounded men with penetrating lesions of the knee must not be transported any distance, and the articulation must ALWAYS BE IMMOBILIZED and covered over with a large dressing. This, we think, is not invariably done.

Treatment.—The first dressing should insure disinfection of the wound and of the surrounding parts (iodine application); it should be occlusive, but not tight.

Immobilization must be strict, brought about at first by the sound limb being fixed to the wounded one; afterwards it will be obtained by a *metallic gutter-shaped splint*, supported above by the thigh, below by the leg and the foot, and leaving the *knee-joint free*, so as to facilitate supervision and dressing (gutter splints with valves).

Very voluminous and very extensive *hæmarthroses* may be drained through a puncture, or, if necessary, by an incision *made and kept* under strict aseptic conditions. It is carried out in the external part of the superior cul-de-sac of the synovial membrane.

In cases of *suppurating arthritis* (great oscillations in the temperature) the joint must be *incised laterally*, following the

internal and external borders of the *patella* to an extent of from 8 to 10 centimetres. The articulation must be thoroughly washed out with hydrogen peroxide, and drained through a transverse drain; the dressing should not be renewed too often. A *crural abscess* should be opened by a deep or *supra-patellar external incision* carried down almost to the bone, a popliteal abscess by a *median vertical incision*, or by the *lateral incision* of Marchal de Calvi, under the internal condyle of the tibia, and *femoral abscesses* by deep external incisions.

Arthrectomy does not seem to us of much use, and we think that excision of the semilunar cartilages or scraping away large portions of bone with the idea of more easily opening the osseous focus should nowadays not be utilized.

We pass over search after *foreign bodies*, which must only be carried out at a late period and with every aseptic precaution after exact indications had been obtained, unless it is a question of shrapnel bullets, in which case extraction should be speedy if not immediate.

Amputation must at first be reserved for cases of gangrene, and afterwards for cases of very grave infective arthritis which has not been modified by arthrotomy. Excision should only be employed at a late period; its indication is exceptional.

Wounds of the Thigh.

The region of the thigh extends from a transverse plane three fingers' breadths from the superior border of the patella to a horizontal line which prolongs both in front and outwards the fold of the gluteal region, the ischium.

Wounds of the thigh are very frequent.

Wounds of the Soft Parts.—Bullets produce on the thigh all the different kinds of lesions, even those that take up the whole length of the part. Sometimes shell fragments give rise to enormous wounds. The interesting

points about these traumatisms are especially in the vasculo-nervous complications.

The arteries in this situation are both numerous and large, hence hæmorrhage from them is very grave. The femoral and its principal branch, the profunda; muscular and perforating branches; the ischiatic artery; besides the big veins, the femoral, the internal saphenous—all these constitute the blood-supply. In the large cellular spaces of the thigh voluminous hæmatomata develop rapidly.

Compression and ligature are the treatments of hæmorrhage, whether immediate or late.

The sciatic nerve, by reason of its size, is not divided by bullets, but is *indented* or *perforated* when it is not merely *contused*.

Large *foreign bodies* often remain lodged in the thigh. In these cases we must remember those that come from the patient's pockets. Direct incisions allow us easily to extract foreign bodies when they have been recognized, and this is not so easy without radiography.

Diffuse abscesses, emphysematous gangrene, are not rare in the thigh. They are often caused by the infection of shrapnel bullets or of shell fragments. Therefore removal of these projectiles must be carried out as soon as possible.

Osseous Lesions.—On the femur we commonly see the most typical diaphysial lesions: *Contusions, fissures, contact fractures, grooves, perforations of one side of the bone, through-and-through perforations, abrasions*.

Contusions are frequent and nearly always unrecognized. The same may be said of *fissures*, which are generally very long.

Contact fractures, transverse and oblique, direct or indirect—that is to say, at some distance from the bony point that has been hit—are by no means rare. They are especially observed in the superior one-fourth or in the inferior one-fifth of the bone,

In contact fractures with large splinters these last are very large (8, 10, 12, 15, 20 centimetres). They give rise to crepitation which may be called "appalling," but it does not become multiplied when they are separated from the fragments. The fractures heal without complications.

The *comminutive* type of contact fractures is also met with in the thigh.

Grooves are often accompanied by oblique fractures.

Perforations of only one side of the bone are rare.

Fracture by through-and-through perforation is a very common osseous lesion.

Adherent splinters are from 8 to 12 centimetres in length; free splinters are also often of a relatively large size (2, 3, 4 centimetres).

These splinters are stationary or forced forward.

On the femur, as on the tibia, at short range, we see *explosive fractures* with a very large aperture of exit.

Treatment.—Fractures of the femur through bullet wounds were considered for a long time as necessitating amputation of the limb; nowadays they ALL can be treated by conservatism, whatever their type, however extensive and complex the osseous comminution and the damage to the soft parts.

Primitive immediate immobilization is obtained at the first-aid stations, at the ambulance, by *fixing the SOUND limb to the wounded one* by bandages, or string, applied on a level with the insteps, and above and below the knees.

Fractures of the femur must be considered as a bar to the patient being transported any distance, at least at first. During the transport the displacements become more prominent and are made worse; the wounded man experiences pains that are followed by muscular reaction; the dressings are easily contaminated by the urine and the fæces. When blood has soaked through the dressings they are rapidly infected.

As final apparatus, *hollowed out gutter splints of iron wire* immobilize badly. Being convex, they give rise to bend-

ing of the callus and render the application of dressings difficult. They should be rejected.

Plaster apparatus immobilize well, but very often they make the application of the dressings difficult.

The *metallic hollowed out gutter splints with valves* are generally sufficient, and render admirable service. When extension is necessary, they effect it in the following manner: Counter-extension is made on the ischium. On this bone rest the zinc lamellæ, which are bent on themselves and held in place by multiple notches made on the upper edge of the gutter. Abdominal bandages, supported at the same time by the bent and padded lamellæ and by an external prolongation of the apparatus, secure the fixity of the counter-extension. Extension is obtained by the traction of the bandages on the foot. We have never treated fractures of the thigh by any other apparatus, and to its employment we owe our great and constant success.

We have recently used our *valvular gutter splint* in a continuous series of twenty-five very serious fractures of the thigh by projectiles; most of the cases had large wounds, also rotation with angular deformations and shortening, which in some reached 8 centimetres. Application of the splint was at once carried out, reduction was well kept up with disappearance of the shortening, besides, dressing was easy whatever the seat of the wounds.

Many surgeons use Tillaux's or Hennequin's extension apparatus. They establish a kind of rigid equation between the employment of these apparatus and our fractures; quite wrongly we think! for these last are often without notable axial displacement. The apparatus in question would seem to us more worthy of recommendation in fractures with axial displacement. But, in our opinion, *they are inferior to the valvular gutter splint because they do not allow the large splinters to draw together their fragments in such a continuous and*

SURE manner, and this is an essential indication in the practice of war surgery ; finally, because with them dressing is not so easy.

It is advantageous to combine immobilization with a *complementary treatment*. In fractures of the thigh we keep our patient constipated for eight or ten days (mucilaginous extract of opium, laudanum), then we open his bowels (oily enemata) only to constipate him again for about the same time. After another motion we may again constipate him for a third time.

During the constipation—that is to say, until the fracture is partly consolidated—we put him almost exclusively on *meat diet*.

The constipation is well borne by young healthy men ; it gives rise to no elevation of temperature, and it has the great advantage of rendering unnecessary that constant supervision which is so tedious and difficult to procure, in order to suppress all movement on the part of the patient, to prevent soiling of the dressings and of the apparatus ; finally, it renders regular consolidation far easier.

In fractures of the upper third it may be necessary to exercise traction in *abduction*, but we think this position ought not to be kept up.

Certain complicated apparatus employed in ordinary practice seem to us to be of very little use, and the *diuretic sanguinary method is especially to be avoided*. It complicates the traumatism, and the points have some difficulty in penetrating and supporting the movable splinters.

We should strive to perfect the final results by using, at the right moment, passive movements of the foot and the knee ; this is easily done with the valvular gutter splint ; we avoid in this way any deformed callus produced by rotation of the foot and bad coaptation of the fragments and of the splinters. Pseudarthroses will to a large extent be prevented if we refuse to perform any operation for the

removal of splinters and if we do not carry extension too far, especially in very comminuted foci.

A cured fracture, with slight or average shortening of the limb, which, however, is in good axial position, is an honour to the surgeon who treated the patient.

When there is abundant suppuration of the focus, we must hasten to remove the free splinters which had been allowed to remain at first. Let us point out that these *will be found in the neighbourhood of the aperture of exit.*

Wounds of the Hip.

The hip comprises the inguino-crural region in front, the gluteal region at the back, and deeply the coxo-femoral articulation.

Articular lesions of the hip are 3·8 per cent. of joint wounds.

Wounds of the Soft Parts.—In this fleshy region the *setons* are extensive, the *culs-de-sac* sometimes complicated by bulky *foreign bodies*. Large fragments of hollow projectiles give rise, on the buttocks and in the groin, to very large, ragged wounds. We have seen some that included the whole of one buttock.

Hæmorrhage from the *groin* is especially serious. Both the femoral artery and vein are of easy access, their relations being so well marked. Their *direct ligature* is the *surgical* treatment of choice in hæmorrhage due to their lateral or central perforation, whilst direct compression is the primary preparatory treatment. This last would be final in some surgeons' hands.

Wounds of the arteries in the gluteal region are formidable. We have seen some of these cases. The big classical incision for the gluteal artery would allow us to verify a difficult differential diagnosis, and to guarantee the application of the proper *surgical* treatment. Immediate com-

pression after freeing the external wound would only be a makeshift. *Tamponment* and pressure must not be maintained for long, owing to their rendering the parts liable to diffuse putrid inflammation.

We have nothing special to say with reference to hæmatomata and to femoral or gluteal aneurysm, or about wounds of the sciatic nerve.

Osseous Lesions.—Openings in the capsule without osseous lesion are exceptional. They are impossible to diagnose.

FEMUR.—The line of the growth cartilage of the femoral head is lost in the anatomical neck.

Another line of cartilage, *oblique below and externally, passes at the base of the great trochanter and separates this base from the remainder of the bone.*

The lesser trochanter is, from the point of view of its constitution, a part superadded to the remainder of the femur.

The limits of the *surgical neck* are—Above, the anatomical neck; below, the intertrochanteric line. Its fibres *that follow the fissural tract* are divided into two fasciculi: one, the internal, large above, goes from the head of the femur to the lesser trochanter that it encircles; the other, the external, has a base corresponding to the head of the femur, and its fibres, some horizontal above, others oblique below, reach the base of the great trochanter and are prolonged under it.

1. The HEAD OF THE FEMUR may be *eroded, hollowed out as with a gouge, perforated*. These lesions are commonly simple, and the anatomical neck raises a bar to the extension of fissures. The cotyloid cavity, its pad, the round ligament, and the capsule, retain the free fragments.

2. Bullets that penetrate on the *level* of the ANATOMICAL NECK *hollow it out as with a gouge, perforate it*, and in the last case may separate the head either incompletely or com-

pletely by a *subperiosteal* fissure. There is no primitive separation.

3. On the SURGICAL NECK bullets may leave simple *indentations*, or give rise to *perforations*, which are either simple or radiated by fissural tracts. The most remarkable of these perforations with fissures is the one in which what may be called the *femoral spur* is separated. This *spur* is represented by a bony wedge that includes the head of the femur, the internal half or third of the surgical neck, and the lesser trochanter (Delorme).

4. *Above the intertrochanteric line* the lesions are of the diaphysial type. The fissures are those of large diaphysial splinters.

Fractures, with solution of continuity of the surgical neck, are very much more uncommon than those with no solution of continuity.

5. THE GREAT TROCHANTER may be *eroded*, *furrowed*, *perforated*; THE LESSER TROCHANTER may be *hollowed out as with a gouge*, *abraded*. These lesions are limited.

6. The COTYLOID BRIM may be *eroded*, *furrowed*. Again, the lesion is limited and simple.

7. When there is penetration *from without inwards* of both the GREAT TROCHANTER and the SURGICAL NECK, there is a tendency to separation of the femoral extremity into one or two incomplete lateral *wedges*, with a diaphysial inferior point; these wedges are always adherent.

Diagnosis.—Diagnosis of osseous lesions of the hip cannot be made by searching only for abnormal mobility, faulty position of the limb, shortening, outflow of synovia, or swelling of the region. These signs are often absent. Localized pain brought about by pressure is an excellent presumptive sign. It would be blamable to endeavour to find abnormal mobility or crepitation. The relationship of the wound to the region occupied by the articulation will specially serve as guide, and, with the indications we have given, will render the diagnosis easy.

1. (a) If we divide into three equal parts the Fallopian line (Poupart's ligament), which extends from the anterior superior iliac spine to the spine of the pubes, the middle segment gives from above the limits of the articulation.

2. Below the limits are fixed by the great and lesser trochanters. The superior border of the great trochanter is easily found. The lesser trochanter corresponds to *the centre* of the anterior surface of the thigh on a horizontal line that, prolonged outwards, would reach the ischium, which is easily felt, or, if preferred, on the line that, prolonged outwards, would reach the inner part of the gluteal fold.

3. Now let us unite by two curves, the superior one concave above, the inferior concave below, the two points limiting the middle segment of the Fallopian line (Poupart's ligament) to the great trochanter on one side, to the lesser trochanter on the other, and we shall then have marked out the area of the head, the anatomical neck, and the surgical neck of the femur IN FRONT.

(b) AT THE BACK we get the same result in the following way: 1. We trace a line that joins the ischium to the most prominent and the most external point of the iliac crest.

2. We ascertain exactly the site of the lesser trochanter. It corresponds to the middle part of the posterior surface of the thigh on the horizontal line that starts at the ischium.

3. We then seek for the prominent border of the great trochanter.

4. If, at a *finger's breadth* above the superior border of the great trochanter, we draw a horizontal line, at the point of meeting of this line with the oblique ilio-ischiatic one already drawn, there we shall find the *upper limit of the head of the bone*. The lower limit of the head corresponds to the meeting of a horizontal line carried a finger's breadth *below* the level of the great trochanter's superior border to the oblique ilio-ischiatic line.

The points that limit the head of the femur thus indicated are afterwards united by curved lines to the great and lesser trochanter.

Thus we find out with sufficient accuracy the posterior area of the head, of the anatomical and of the surgical neck. The line between the trochanters separates that which is in relation to the epiphysis above and to the diaphysis below.

Later on, radiography will furnish very important information in the diagnosis, especially in cases of epiphysal-diaphysal lesions.

Prognosis.—Formerly, prognosis of bullet wounds of the hip, with osseous lesions, was extremely severe. In the War of Secession the mortality was 84·7 per cent.; in the Franco-German War, 79·7 per cent. In the Cuban War it was 33 per cent., and in the Transvaal 28·6 per cent.

It was the suppurating arthritis of the joint that brought about the death of the wounded men; and in those unfortunately too rare cases that recovered an ankylosed articulation was left. Nowadays cure is frequent, and very often the mobility of the joint is preserved.

Yet infectious complications are still observed, such as large hæmatomata or foreign bodies, whose appearance is stimulated by the neighbourhood of the rectum and bladder.

The prognosis of wounds of the hip by firearms is influenced by that of the complications, and especially by grave hæmorrhage.

Certain conditions, in our opinion, seem to mitigate the prognosis; for example, wounding of the joint by a bullet fired point-blank from a great distance, which gives rise to very small lesions; or absence of a posterior wound, which is so easily infected. In posterior osseous lesions the neck of the femur is to a large extent untouched; communicated infection is much easier when the track is widely open. In

the anterior cul-de-sac wounds the thick capsule, the fibres of which have been separated, is in a certain measure an obstacle to infection.

Treatment.—Men with *fractured hip should never be transported to any distance*. Immediate immobilization is obtained by bringing together the two lower limbs. This method of temporary immobilization can still be of use as an ultimate measure when there is no osseous solution of continuity.

To immobilize the hip, various means have been proposed: decubitus on a well-padded plank, in Bonnet's gutter apparatus; the employment of Smith's splint, which takes its point of support from the whole of the anterior surface of the limb; the external splints of Desault and Isnard; large plaster apparatus; and, finally, various extension apparatus. We do not believe that the first-mentioned apparatus are necessary. There is no assimilation possible between lesions by firearms and ordinary fractures; and, on the other hand, *extension creates the danger of separation of the fragments*. As a general rule, we think that bringing together the lower limbs is sufficient.

In order to avoid any displacement of the fragments occurring, and also the pain which always accompanies the movements rendered necessary for alvine discharges, we *constipate* these patients as we do those with a fractured thigh.

The dressings must be large, going very much beyond the limits of the region; at the very least they should reach as far as the groove between the nates, and, above all, they should remain fixed in place. Now, what dressings realize these conditions at the present time? To obtain them it is necessary for a large compress—applied in the manner recommended by Mayor, taking its point of support from circular abdominal bandages or from a body bandage, and below from circular crural bandages, and then consolidated by a spica—entirely to cover a large mattress made of

aseptic material. But we still ask for more, and we advise all surgeons to follow our practice, which consists in covering *all* the regions: inferior abdominal, crural, gluteal and perinæal. The constipation of the patient allows us to do this; besides, it simplifies to a large extent the nursing.

Immediate extraction of free splinters is not necessary, but, in an infected focus, it may be obligatory, and still more, at the time of removal, we may find ourselves, in these cases, compelled to take away, with the splinters, osseous fragments of the head of the bone and even part of the surgical neck (spur). We must, however, be sparing with these operations, and only perform them in good earnest when driven by necessity. *A fortiori we must not endeavour to do a typical resection.*

The *anterior* incision of Hueter outside the femoral vessels brings us well and directly down on the joint, on the head, and on the neck of the femur. At the back, an incision following the direction of the fibres of the gluteus maximus allows us to bring into view the head, the neck, and the great trochanter, and, if necessary, the acetabulum. The difficulty does not lie so much in the exposure of the joint as in the removal of splinters that are partly adherent. We should proceed by successive freeing.

In no case should we resect under the line between the trochanters. The result is deplorable.

Abscesses are reached *in front* by the incision for ligature of the femoral, *at the back* by the gluteal incision.

Primitive disarticulation of the hip-joint is contra-indicated in bullet lesions with no complications. It may become necessary owing to gangrene or to nearly total abrasions produced by large shell fragments with laceration of the vessels and of the nerves, or subsequently owing to femoral osteomyelitis. The anterior racket operation with preliminary ligature of the artery is the procedure of choice.

INDEX

- ABDOMEN, regions of, 168
 Abdomen, wounds of, 167; non-penetrating and penetrating, 169; diagnosis, 173; course and prognosis, 174; treatment, 176
 Abrasions, 104, 146; partial, 54; total, 55, 57, 207, 232
 Abscess, cerebral, 139; perirectal, 188
 Acromion, 159
 Action, divulsive and propulsive, 10
 Active power, 7, 22
 Adrenalin, 53
 Alcohol, 165
 Alum, 53
 American Civil War, 43, 102, 118, 142, 175, 177, 240
 Amputation, 102, 110, 122, 126, 215, 221, 226, 231
 Anæmia, acute, 46, 47
 Anatomical neck (femur), 237
 Aneurysmal varix, 51
 Aneurysms: traumatic, 49; arterial, 49
 Ankylosis, 209
 Anodynes, 164
 Antipyrin, 53
 Antitetanic serotherapy, 116
 Anuria, 182
 Anus, escape of blood through, 173
 Aperture: entry, 24, 104, 111; exit, 25, 104, 111
 Apparatus, 96
 Apparent death, 48
 Arm, wounds of, 210
 Arteries, wounds of, 36; prognosis, 40
 Arterio-venous aneurysms, 50
 Arthrectomy, 231
 Arthritis, 110
 Articulations: lesions of, 103; types, 106; diagnosis, 107; prognosis, 108; treatment, 109
 Assaky, 59
 Astragalus, 221
 Austrian bullets, 3, 4, 170
 Autograft, 60
 Autoplasty, 145
 Auvray, 139, 140
 Bacillus, Vincent's, 116
 Balkan War, 1, 36, 39, 41, 43, 92, 101, 164, 177, 193, 195
 Ballistic data, 5; shells, 20
 Bartels, 186
 Bascule movements, 6
 Bayonets, 1
 Belgian bullets, 3, 4
 Billet, H., 33, 139, 140
 Bladder, wounds of, 185; diagnosis and prognosis, 185; treatment, 186; puncture of, 188
 Boeckel, E., line of, 198
 Bonnet's splint, 194
 Bornhaupt, 44, 50
 Brachial artery, 206
 Brain, wounds of, 128; diagnosis, 132; evolution, 135; prognosis, 135; treatment, 136; complications, 138
 Brentano, 45
 Buccal floor, wounds of, 151
 Bullets, 2, 3, 4, 5, 61, 62, 63, 64, 65, 66; *modus operandi* of, 9; humanitarian, 12; explosive or dum-dum, 14; from shells, 28, 66, 92; change of shape, 65, 88, 175
 Bursting height, 21
 Caffeine, 165
 Callus, painful, 107
 Camphorated oil, 165

- Carbolic acid, 34, 35, 100
 Carotid arteries, wounds of, 153
 Carrel, 46
 Carrière, 34
 Cartilage, growing, 104, 206
 Case-shot, 19
 Catheterism, 186, 188
 Cerebral shock, 134
 Cerebro-medullary shock, 195
 Cerebro-spinal fluid, escape of, 192
 Champenois, 98, 210
 Chauvel, 36
 Chavassee, 176
 Cheeks, wounds of, 151
 Chenu, 48
 Chest, wounds of, 158; non-penetrating, 158; penetrating, 161; zones of, 162, prognosis, 166
 Cheyne-Stokes respiration, 192
 Chloride of calcium, 53
 Chloroform, 115
 Circular ligation of the limbs, 165
 Clavicle, 158
 Clothing: fragments of, 66; examination of, 67
 Cold steel, 1, 2, 71, 128, 169
 Commminution, 87
 Complications, general, 113
 Compression, 47; digital, 41; indirect, 53; mechanical, 41; distal, 47; direct, 53; cerebral, 134; cord, 191, 225, 227, 232
 Conservatism, 94
 Constipation, 235
 Contusions, 23, 36, 43, 46, 54, 71, 104, 111, 112, 123, 128, 129, 132, 134, 146, 149, 153, 154, 158, 160, 169, 181, 185, 191, 204, 210, 224, 232
 Coracoid process, 159
 Cornea, lesions of, 147
 Courtot, 34
 Cracks, 72, 128, 129, 132, 204
 Crimea, 115, 175
 Crushing, 112, 123
 Cuban War, 64, 240
 Cul-de-sac wounds, 151, 161, 169, 171, 181, 185
 Cuneo, 60
 Cystotomy, suprapubic, 187
 De Calvi, Marchal, 231
 Deflection movements, 6
 De Giry, Chasteney, 139
 Delirium, nervous, 113
 Deljalitzky, 138
 Delorme, 36, 66, 97, 129, 142, 159, 176, 178, 199, 219
 De Moy's splint, 97
 Dent, 193
 Depressions, 128, 129, 132
 Diaphyses, bony lesions of, 71; diagnosis, 84; prognosis, etc., 89; complications, 91; treatment, 94; resection of, 102
 Diet, 148
 Dieulafoy, 122
 Disarticulation, 216, 242
 Division, complete, 39
 Drain, regrettable, 100
 Dressing, 33
 Dressing-pocket, 31
 Dorsalis pedis artery, 219
 Dyspnoea, 162
 Ear, lesions of, 147
 Elbow, wounds of, 206; diagnosis, treatment, 208
 Emphysema, 155, 162, 165
 English bullets, 3, 4
 Epilepsy, traumatic and Jacksonian, 143
 Epiphysis, 104, 198
 Ergotine, 53
 Erosions, 23, 104
 Erysipelas, surgical, 118
 Ether, 165
 Excision, atypical, 216
 Excoriations, 181, 185, 217
 Extension, forced, 41
 Extirpation (aneurysms), 52
 Eye, wounds of, 145
 Face, wounds of, 145
 Fæcal matter, escape of, 187
 Femoral artery, 232
 Femur, 228, 233, 237
 Ferraton, 19, 39, 118, 119, 135, 152, 155, 156, 170, 179, 200, 205, 209, 217
 Fessler, 36
 Fibula, 223, 229

- Fingers, wounds of, 197; complications, 198; treatment, 199
 Firearms, 2
 First Empire wars, 115
 Fissures, 72; symmetrical, opposite, 73; concentric, 111, 128, 129, 131, 132, 158, 161, 198, 204, 210, 224, 232
 Flat bones, lesions of, 111
 Flexion, forced, 41
 Focus, the osseous, 83; anti-sepsis of, 100
 Foot, wounds of, diagnosis, complications, 218; treatment, 220
 Foratini, 59
 Forearm, wounds of, 204; treatment, 205; prognosis, 206
 Foreign bodies, 92, 101, 124, 148 (ear), 160, 174, 186, 199, 232
 Foreign bodies (clothes), 35, 61, 66; diagnosis, 68, 89; treatment, 69; cerebral, 141
 Fourmies, 65
 Fowler's position, 178, 179
 Fractures, contact, 73, 86, 149, 158, 198, 204, 210, 223, 224, 232; with large splinters, 86, 149, 158, 198; and transverse and oblique, 74; by perforations, 86; by groove, 87; consecutive care of, 101; of inner table, 129; tangential, 149; clean, 207
 Fragments, 40
 Franco-Prussian War, 50, 240
 French bullets, 3, 4
 Freyer, 54, 58
 Furrows, 23, 104, 111, 112, 129, 151, 161, 171, 191, 203, 207
 Fuse, percussion and time, 17, 21
 Gangrene, 92, 114; traumatic, 92; hospital, 116; emphysematous, 119, 232
 Gargling, 148
 Gelatine, 53
 Genital organs, wounds of, 188
 German bullets, 3, 4
 German wars, 102
 Glenoid cavity, 214
 Glycerine, carbolyzed, 147
 Grazings, 128
 Grenades, 19
 Grooves, 80, 89, 104, 111, 128, 129, 158, 160, 171, 191, 198, 203, 204, 207, 224, 232
 Gross, 114
 Guérin, A., 94, 119
 Guns, 16
 Hæmarthrosis, 229
 Hæmatemesis, 173
 Hæmatomata, 152, 153, 155, 227
 Hæmaturia, 182, 185
 Hæmoptysis, 162
 Hæmorrhage, 48, 151, 153, 155, 156, 160, 172, 173, 183, 189, 192, 198, 219, 224, 227, 236; late and secondary, 52; primary, 91
 Hæmothorax, 165
 Haga, 176
 Hands, wounds of, 197; complications, 198; treatment, 199
 Harris, 179
 Hashimoto, Dr., 59
 Hearing, diminution or loss of, 147
 Heart, wounds of, 166
 Hennequin, 98, 210, 234
 Hernia of the brain, 140
 Hernia of the lung, 163
 Hildebrandt, 40, 50
 Hip, wounds of, 236; diagnosis, 238; prognosis, 240; treatment, 241
 Hispano-American War, 156
 Holbeck, 115, 142
 Horsley, 139
 Hot water, 53
 Howitzer shells, 17
 Hueter, 242
 Humanitarian bullets, 12
 Humerus, 207, 213
 Hydrogen peroxide, 35, 90, 100, 121, 148, 200
 Immobilization, 94, 110, 150, 159, 160, 162, 176, 210, 225, 233, 241
 Incision, buttonhole median perineal, 187; lateral, 211; external, 212; shoulder-joint, 216
 Indentations, 43, 111, 154
 Infection, perirectal, 187

- Instep, wounds of, 221 ; diagnosis, treatment, 222
 Intestine, lesions of, 169
 Intrarhachidian abscess, 193
 Iodine, 33, 34, 35
 Iodoform gauze, 100, 148 ; ointment, 146
 Iris, lesions of, 147
 Irrigations, 148
 Italian-Turkish War, 177
 Jaundice, 173
 Journée, 9
 Karbine, 89, 138
 Kidneys, wounds of, 181 ; pelvis of, 182 ; treatment, 182
 Kirmisson, 48
 Knee, wounds of, 226 ; diagnosis, prognosis, 229 ; treatment, 230
 Kuttner, 40
 Laminectomy, 193
 Lance, 2
 Laparotomy, 177, 179, 187
 Larrey, 96, 186
 Larynx, 154
 Lasègne, 142
 Laurent, Professor, 49, 50, 59, 60, 158, 162, 166, 191, 193, 195, 196
 Ledran, 216
 Leg, wounds of, 223 ; diagnosis, treatment, 224
 Legal position of soldiers wounded in the skull and brain, 143
 Lidell, 43
 Ligature, 44, 45, 47 ; at a distance, 52 ; in the sac, 52, 232
 Lips, wounds of, 151
 Liver, 171
 Loison, 43
 Lower limbs, wounds of, 217
 Lucas-Championnière, 125
 Lumbar region, wounds of, 181 ; treatment, 182 ; incision, 183
 Lungs, wounds of, 161 ; diagnosis, 162 ; complications and treatment, 163
 MacCormac, 177
 Makins, 42, 186
 Manchurian Campaign, 34, 43, 44, 45, 50, 92, 101, 118, 138, 177
 Manteuffel, 44
 Matthew, 37
 Maxilla, inferior, wounds of, 149
 Maxillæ, upper, wounds of, 148
 Mayor's cravat bandage, 41 ; apparatus, 97, 221, 241
 Medullo-rhachidean lesions, diagnosis, 192 ; prognosis and treatment, 193
 Meningo-encephalitis, 138
 Meningo-medullary lesions, 191
 Mercury, bichloride, 34
 Meslier, 139
 Metacarpals, 198
 Mignon, 139
 Mineral waters, 102
 Mitraillease, 5
 Morel's garrot, 41
 Morocco Campaign, 51, 177
 Movement, passive, 110
 Murphy's incision, 179, 187
 Musculo-spiral nerve, 210
 Mutilation, self-, 200
 Nancy, 179, 180
 Nape of the neck, wounds of, 152
 Neck, wounds of, 152 ; antero-lateral regions, 153 ; diagnosis, 154 ; prognosis, 155 ; treatment, 156
 Nephrotomy, 183
 Nerves, wounds of, 54, (neck), 154 ; signs of, 55 ; diagnosis, treatment, 56
 Neuritis, 60
 Neuromata, 59
 Neurotomy, 60
 Neurotripsy, 60
 Normal saline, 48
 Nose, wounds of, 145
 Notches, 159, 160
 Nusbaum, 49
 Œsophagus, 154
 Oliguria, 182
 Ophthalmia, sympathetic, 146
 Orbit, wounds of, 145
 Oscillation movements, 6
 Osteomyelitis, 93
 Otis, 43, 191, 192
 Pain, 113

- Palmar incisions, 129
 Pancreas, 172
 Paré, 96
 Patella, 228
 Pauzat, 217
 Pellerin, 34
 Pelvic bones, lesions of, 184
 Pelvis, wounds in the region of, 184
 Penetrating wounds, 103, 104, 161
 Penetration, 8
 Penis, 189
 Perforation, 77, 88, 112; complete, 38, 111; lateral, 43; central, 43; total, 46, 54, 57, 78, 104, 151; incomplete, 77, 104, 111; through - and - through, 128; single and double, 129, 130, 135; tangential, 131; frontal, parietal, temporal, occipital, vertical, 134, 146; (eye), 153, 154, 159, 160, 161, 169, 171, 181, 185, 191, 198, 203, 204, 207, 224, 232
 Peri-articular wounds, 226
 Peritonitis, 172, 174
 Phalanges, 198
 Pharynx, 154
 Pirogoff, 43; pouch of, 25
 Plantar arteries, 219
 Plaster apparatus, 97
 Pleurisy, 163, 165
 Pneumothorax, 162
 Poirier, 139
 Poncet, 114
 Popliteal vessels, 226; nerves, 227
 Potassium permanganate, 148
 Pravaz syringe, 48, 122, 165
 Preterre, 151
 Profunda artery, 232
 Projectiles, 2; secondary, 9, 10; pointed, 10; lesions caused by, 71; large, 123, 131; wind of, 123
 Prostate, wounds of, 188
 Prosthesis, 145
 Pseudo-arthroses, 101
 Pyæmia, 118, 119
 Pyonephrosis, 183
 Quinine, 53
 Radiography, 73, 87, 108, 141, 146, 160, 208, 215
 Radius, 206, 207
 Range, 7
 Raoult-Deslonchamp's apparatus, 98, 222, 225
 Reclus, 124
 Rectum, wounds of, 184, 187
 Reduction of fracture, 99
 Reeb, 114
 Resection: atypical, 110, 209; typical, 242
 Retzius, cavity of, 185
 Reverdin, 67
 Revolver shots wounds, 28
 Ribs and cartilages, 160
 Ricochets, 8
 Robert, 34
 Rohmer, Professor, 179
 Rouvillois, 51
 Rupture (eye), 146
 Russian bullets, 3, 4, 170
 Russo-Japanese War, 34, 41, 115, 175, 177
 Russo-Turkish Campaign, 118 230
 Sabre, 2
 Sac, incision of, 52
 Saïgo, 50
 St. Petersburg, riot in, 65
 St. Quentin, 114
 Sarrazin's apparatus, 97
 Scalp, wounds of, 128
 Scapula, 159
 Sciatic, lesions of, 184
 Sclerotic, lesions of, 147
 Scrotum, 188
 Sections, 46
 Septicæmic fever, 119
 Serum: antidiphtheritic, 53; horse, 53
 Setons, 24, 151
 Shells: Field Artillery, 16; mitraille, 17, 20; systematic bursting, 17; explosive, 18, 20, 22; mixed universal, 19; bursting of, 40; armour-piercing, 124
 Short bones, lesions of, 111, 112
 Shoulder, wounds of, 212; diagnosis, 214; treatment, 215
 Shrapnel, 17, 18

- Skull, wounds of, 128 ; diagnosis, 132 ; evolution, 135 ; prognosis, 135 ; treatment, 136 ; complications, 138
- Soft parts, wounds of, 23, 28
- Souffle, 49
- Souligoux, 179
- Sphincter ani, dilatation of, 187
- Spinal cord, wounds of, 190
- Spine of scapula, 159
- Spleen, 171
- Splinters, shell, 28, 92 ; small, 40 ; free, 81, 100 ; adherent, 82
- Stenon's duct, 151
- Sternum, 160
- Stomach, 171
- Strasbourg, 114
- Stupor, local and general, 114
- Subclavian arteries, wounds of, 153
- Sulphuric ether, injections of, 48
- Suppuration, 42, 90, 93, 100, 117, 160
- Surgical neck (femur), 237
- Suture of arteries, 45 ; in aneurysms, 52 ; of nerves, 59
- Sword, 2
- Syme, 221
- Symptomatology, 40
- Symptoms, consecutive (skull, brain), 141
- Syncope, 48
- Takuoka, Dr., 59
- Tarsus, 218
- Tearing away of tissues, 123, 169
- Testicle, 189
- Tetanus, 115, 220
- Thigh, wounds of, 231 ; treatment, 233
- Thoraco-abdominal wounds, 165
- Thrace Campaign, 118
- Thyroid, 154
- Tibia, 224, 228
- Tillaux, 234
- Tissues, elastic, 10
- Toes, 218
- Tongue, wounds of, 151
- Trachea, 154
- Tracheotomy, 157
- Track, 25, 104
- Trajectory, 7
- Transfusion, 48
- Transporting wounded, 41
- Transvaal War, 41, 43, 74, 115, 175, 176, 177, 186, 193, 240
- Traumatopnœa, 162
- Treatment, 31, 41, 49
- Trifaid, 121
- Trochanter (femur), great, lesser, 38
- Tubulization (nerves), 59
- Ulna, 206, 207
- Upper limbs, wounds of, 197
- Ureter, 182
- Urethra, wounds of, 188
- Urine, infiltration of, 182 ; escape of, 185, 188
- Van Lair, 59
- Veins, wounds of, 46 ; big veins (neck), 153
- Velocity, 107 ; transit, 5 ; of rotation, 6 ; initial, 5, 6 ; remaining, 5, 6 ; muzzle, 5, 6 ; excessive, 131
- Velpeau, 159
- Vertebral column, wounds of, 190
- Vessels, lesions of, 36 ; complications, 47
- Vis viva*, 7
- Weapons, 1 ; of offence, 2
- Weir Mitchell, 55
- Weiss, Professor, 180
- Wounds, contour, 161
- Wounds, tissues, 23 ; cul-de-sac, 24 ; enfilade, 27 ; lateral, 38, 46 ; gaping, 39 ; dressing of, 39 ; periarticular, 103
- Wrist, wounds of, 202 ; diagnosis treatment, 203
- Zinc chloride, 35, 100
- Zinc gutter splints, 97
- Zones of action (bullet), 11

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